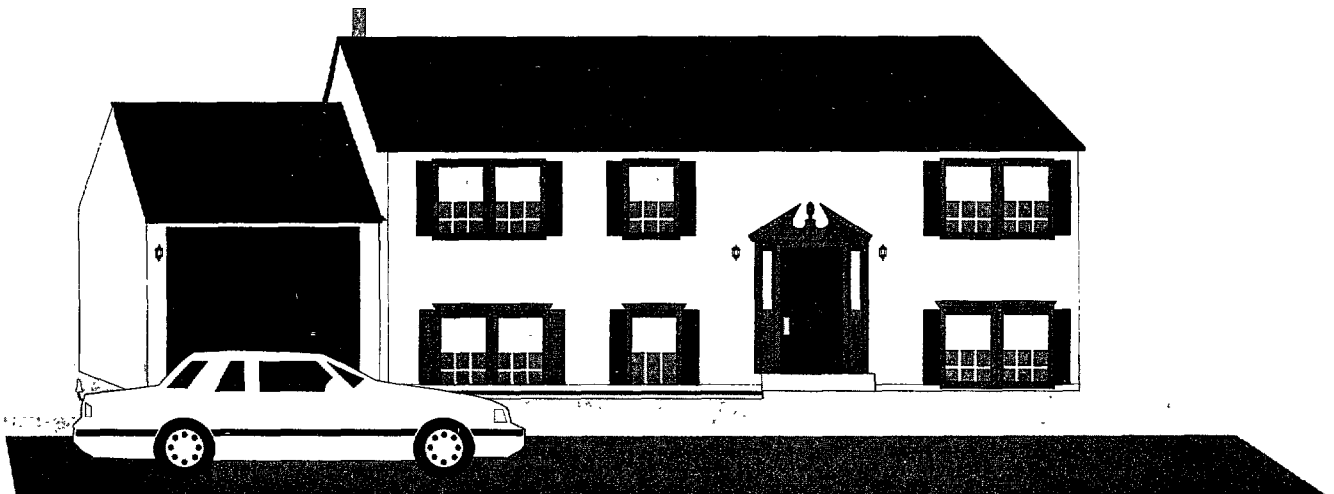
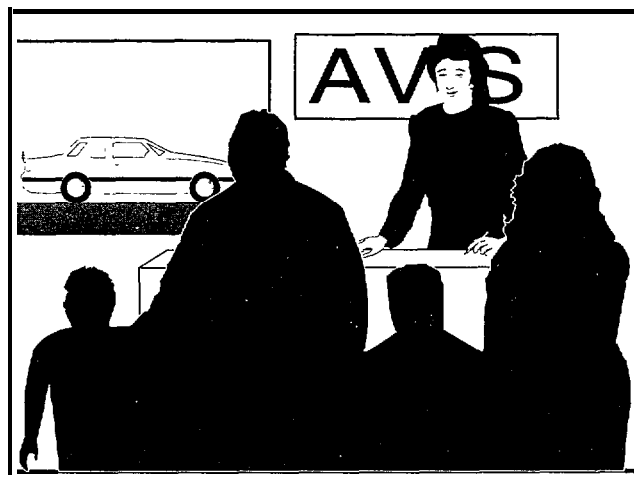


TravTek Evaluation Rental and Local User Study

Publication No. FHWA-RD-96-028

March 1996



U.S. Department of Transportation
Federal Highway Administration

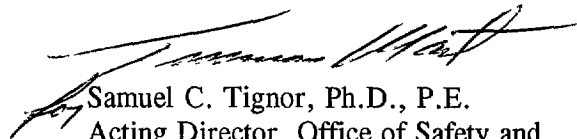
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FOREWORD

This report is one of eight reports produced as part of the evaluation of the TravTek operational field test, conducted in Orlando, Florida, during 1992-1993. TravTek, short for Travel Technology, was an advanced driver information and traffic management system that provided a combination of traveler information services and route navigation and guidance support to the driver. Twelve individual but related studies were conducted during the evaluation. Evaluation goals and objectives were represented by the following basic questions: (1) Did the TravTek system work? (2) Did drivers save time and avoid congestion? (3) Will drivers use the system? (4) How effective was voice guidance compared to moving map and turn-by-turn displays? (5) Was TravTek safe? (6) Could TravTek benefit travelers who do not have the TravTek system? (7) Will people be willing to pay for TravTek features?

Evaluation data were obtained from more than 4,000 volunteer drivers during the operation of 100 specially equipped automobiles for a 1-year period. Results of the evaluation demonstrated and validated the concept of in-vehicle navigation and the provision of traveler information services to the driver. The test also provided valuable results concerning the drivers' interaction with and use of the in-vehicle displays. This project has made many important contributions supporting the goals and objectives of the Intelligent Transportation Systems Program.



Samuel C. Tignor, Ph.D., P.E.
Acting Director, Office of Safety and
Traffic Operations Research and
Development

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16. Abstract <p>The Rental User Study and Local User Study were conducted as part of the TravTek Operational Test Evaluation. TravTek was an operational field test of an advanced traveler information and traffic management system (ATIS/ATMS). As part of the test, 75 TravTek equipped vehicles were rented to Orlando visitors. Other TravTek equipped vehicles were supplied to Orlando residents who were selected in part because they compile above average mileage in their daily driving. There were 2,896 TravTek rentals that averaged 4 to 6 days. Fifty-one local users were each given use of a TravTek vehicle for approximately 2 months.</p> <p>The focus of these evaluation studies was to obtain user perception and performance data related to use of system components in the TravTek vehicles. The vehicles were equipped to provide route planning, route guidance, and a data base of local services and attractions. The in-vehicle system included moving map and simplified turn-by-turn guidance displays supplemented by a synthesized voice guidance and traffic report feature. Questionnaires, debriefings, and automated in-vehicle data logs were used to gather evaluation data. Measures described in this report include: perceptions of utility, ease of use, safety, driver workload, frequency of use of system functions and features, and estimates of willingness-to-pay for the TravTek system as a whole, as well as for selected features.</p> <p>Both rental and local users reported the route planning and route guidance features of the TravTek system to be useful and easy to use. Users reported that they felt more attentive and less distracted when driving with the TravTek system compared to driving in similar situations without the system. TravTek was used on more than half of all trips. Renters with route planning and route guidance capabilities used those capabilities on more than half their trips. Local users also made extensive use of the route planning and route guidance capabilities. In route guidance, rental users drove most of the time with the simplified Turn-by-Turn Guidance Display with the synthesized voice supplement turned on. Although local users expressed a slight preference for the moving map Route Map display without the supplemental voice, they also used the Guidance Display with voice supplement on more than other display options. Users estimated that they would be willing to pay about \$1000 for a system such as the one they drove. Users also indicated that they were willing to pay the most for navigation, route planning and route guidance features, and somewhat less for real-time traffic information and local information data bases.</p>			
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yards	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.71	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact)				
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

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OVERVIEW

TravTek, short for “Travel Technology,” was an Intelligent Transportation System (ITS) operational field test. The purpose of TravTek was to perform research, development, test, and evaluation of advanced traveler information system (ATIS) and advanced traffic management system (ATMS) concepts.

TravTek was the largest, most comprehensive ATIS operational test attempted to date in the United States. It officially started on March 23, 1992, and operated for 1 year. TravTek was a partnership between the private sector and the public sector. The private sector was represented by General Motors and the American Automobile Association. The public sector was represented by the Federal Highway Administration, the Florida Department of Transportation, and the City of Orlando.

The TravTek evaluation consisted of a series of interrelated research efforts that addressed every facet of the system. The Rental User Study and the Local User Study were two of those efforts, and the results of both are presented in this report. Together, these two naturalistic field studies examined how end users would perceive and use the TravTek system when they were free to use the system as they desired. Rental User Study participants were visitors to the Orlando area who rented TravTek equipped vehicles from Avis Rental Car, Inc. The average rental varied from 4 to 6 days. Local User Study participants were Orlando residents who were selected, in part, because they drive a lot in the Orlando area. Local Users were given the vehicles to use free of charge for 2 months.

The studies examined users’ perceptions of the effects of TravTek on their driving behavior. User preferences for display options and system features were examined, as were perceptions of benefits such as safety, usability, navigation efficiency, and congestion avoidance. In-vehicle data logs also recorded when and how the TravTek system was used.

The results show that TravTek was perceived favorably by both rental users and local users. Drivers reported that the system helped them find their way, helped them pay more attention to their driving, and to drive more safely. The synthesized voice guidance system that supplemented the visual route guidance displays was favorably received, and was used on most trips. Rental and local users indicated that they would be willing to pay about \$1000 for a complete TravTek system.

INTRODUCTION

TravTek was a joint public and private sector operational field test of an advanced traveler information and traffic management system (ATIS/ATMS).^(1, 2) Public sector participants were the City of Orlando, the Federal Highway Administration (FHWA), and the Florida Department of Transportation. The American Automobile Association (AAA) and General Motors were the private sector participants.

The TravTek Evaluation consisted of a series of behavioral, engineering, and modeling studies designed to evaluate the TravTek system from multiple perspectives. The *Rental User Study* and *Local User Study* were among the evaluation studies conducted as part of the TravTek Operational test. The goal of the rental and local user studies was to provide both performance and questionnaire data from participants who were free to use the system as they desired. Rental User Study participants were primarily visitors to the Orlando area who rented TravTek vehicles from Avis Rental Car, Inc. Local User Study participants were Orlando residents who were each given use of a TravTek vehicle for approximately 2 months.

The purpose of this introduction is to provide:

1. An overview of the TravTek system.
2. An overview of the TravTek Evaluation.
3. A brief introduction to the Rental User Study and Local User Study.
4. A comprehensive summary of the goals and objectives of the Rental User Study and Local User Study.

Following the Introduction, the Methods section provides additional details on the research approach for the two studies. The Results section integrates the findings from both studies so that comparisons of findings across the contrasting driving populations is facilitated. Similarly the Discussion and Conclusions represent an attempt to integrate findings from both studies.

OVERVIEW OF THE TRAVTEK SYSTEM

The TravTek system was composed of three primary components:

1. The TravTek vehicles.
2. The Traffic Management Center (TMC).
3. The TravTek Information and Services Center (TISC).

Figure 1 presents an overview of the TravTek system architecture. The three components of the TravTek system were described in detail by Rillings and Lewis.⁽³⁾

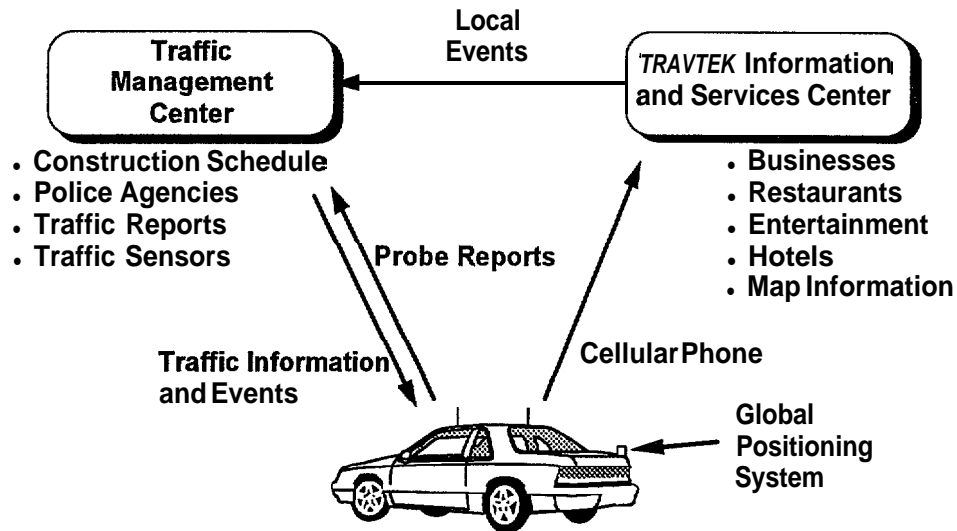


Figure 1. Overview of the TravTek system,

Each of the TravTek partners were responsible for providing and maintaining specific sub-systems. General Motors' responsibilities included providing the vehicles, the interface between the TMC and test vehicles, a data base, and systems engineering. FHWA provided the system manager for the TMC, leasing of the radio subsystem, assisted the City of Orlando in operating and maintaining the TMC, and contracted for a system evaluator. The AAA provided the TravTek Information and Services Center (TISC). The City of Orlando provided coordination of the TMC with other traffic management facilities, space, TMC hardware and software, and an interface with the city's traffic signal system. The Florida Department of Transportation provided the free-way surveillance system on I-4, the interface of the surveillance system with the TMC, and maintenance of the TravTek traffic link-node data base.

The TravTek In-Vehicle System

There were 100 TravTek vehicles. The TravTek vehicles had a two-way communications link with the TMC and communicated with the TISC help desk via hands-free cellular phone. Once each minute, computers in the TravTek vehicles received broadcast information from the TMC. In turn, once each minute computers in the vehicles broadcast to the TMC vehicle location and travel times across any TravTek traffic links the vehicle may have recently traversed. A variable-scale color map, and other TravTek visual information, were presented on a 127-mm video display. The video display, an option on the Oldsmobile Toronado, was positioned high on the dashboard to the driver's right. The in-vehicle system also presented drivers with audio messages that were generated by a synthesized voice system. The human factors considerations in the design of the TravTek in-vehicle driver interface are described by Carpenter, Fleischman, Dingus, Szczublewski, Krage, and Means.⁽⁴⁾

TravTek vehicles provided drivers with a wealth of information. Some of the features of the TravTek system were:

- **Local Information** — TravTek vehicles carried an onboard data base of information intended to be useful to drivers. The Services and Attractions Directory included time sensitive information such as weather and local events and was regularly updated by the TISC and broadcast from the TMC. The Services and Attractions Directory included information on accommodations, restaurants, attractions, bank automatic teller machines, and a variety of other services. Once selected, any service or attraction in the directory could be displayed on an electronic map, one-touch dialed on the cellular phone, and (if the vehicle was so configured) made a destination for route planning and guidance. Figure 2 shows an example of a Services and Attractions screen that shows information regarding one establishment .



Figure 2. An example of a screen from the local information data base

- **Navigation** — The navigation system used a combination of dead-reckoning, map-matching, and Global Positioning System information to indicate the vehicle's position on a color moving map display. The vehicle's position was indicated by an icon that was horizontally centered three-fourths of the distance from the top of the screen. When the vehicle was in PARK the map could be switched between north-up and heading-up. When the vehicle was in DRIVE the map was displayed in a heading-up format. Figure 3 provides an example of a navigation display.

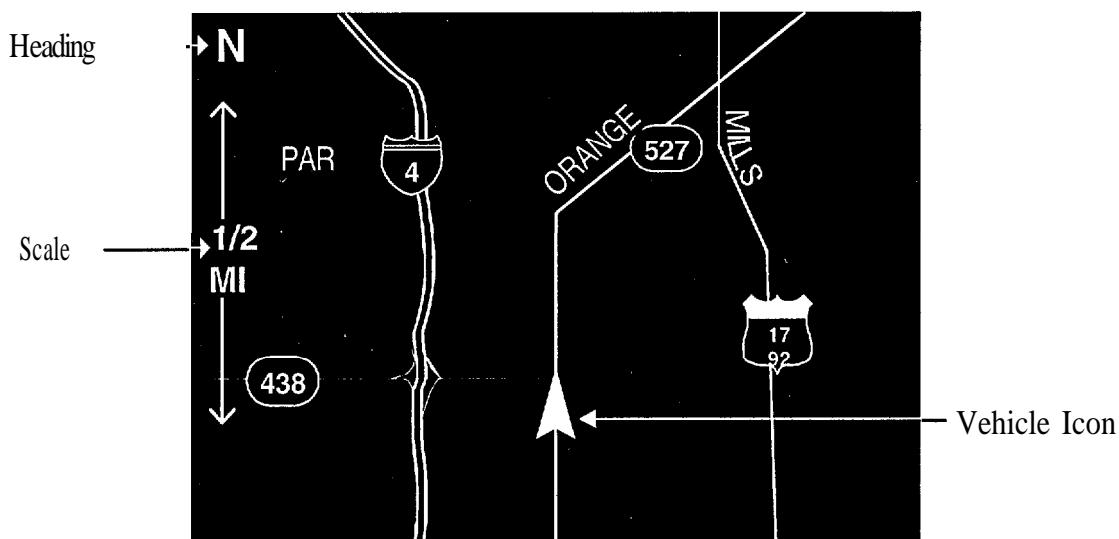


Figure 3. TravTek navigation display.

- Route Selection** — Users could input a destination into the system and the system would plan a route from the vehicle's present location to that destination. Destinations could be entered as intersections, street addresses, street names, or selected from the Services and Attractions Directory. An in-vehicle routing computer provided the minimum-time route from the vehicle's current position to a selected destination. The minimum-time criterion was subjected to constraints such as turn penalties, preference for higher level roadways, and avoidance of short-cuts through residential areas. Users could influence the routing by selecting among three route planning criteria: fastest, avoid Interstates, or avoid tolls.
- Route Guidance** — If the system was used to plan a route, a sequence of guidance displays provided maneuver-by-maneuver driving instructions. The **Guidance Display** is illustrated in figure 4. Although the Guidance Display was the default route guidance display, the driver could switch between it and a **Route Map**. The Route Map showed the planned route as a magenta line traced over the navigation display illustrated in figure 3. A button on the steering wheel hub provided the means for switching between the Guidance Display and the Route Map. The visual guidance displays could be augmented by a **Voice Guide**: synthesized voice messages that provided the next turn direction, distance to the turn, and the name of the street on which to turn. By default, the Voice Guide was on, but it could be turned off or on using a button on the steering wheel hub. Another button on the steering wheel hub caused recent voice messages to repeat.

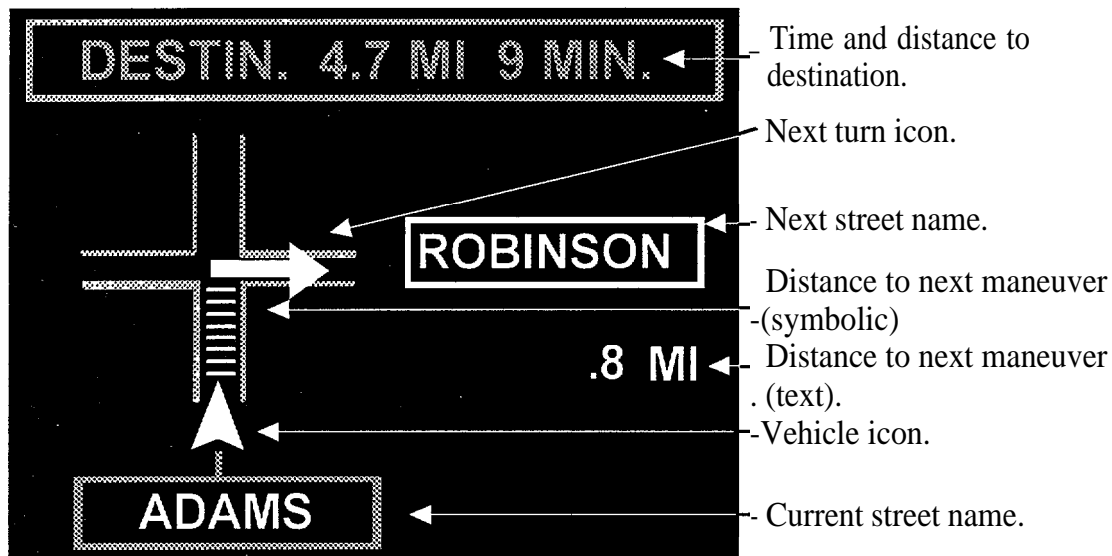


Figure 4. The TravTek Guidance Display.

- **Real-time Traffic Information** — Real-time traffic information was broadcast to computers in TravTek vehicles once every minute. To limit the quantity of information broadcast, only exceptions to normal traffic flow were reported. The real-time information could be used in route planning. Also, if conditions changed while the vehicle was en route; a new, faster, route could be offered to the driver. Conditions available to the vehicle system via broadcasts from the TMC included:
 - Historical travel times as a function of time of day and day of week.
 - Travel times computed from roadway sensor data (e.g., from roadway loop detectors).
 - Police reports,
 - City reports of maintenance and road closures.
 - Travel times based on probe reports from other TravTek vehicles for TravTek traffic links (roadway segments).

When the real-time information function was active and a route was planned, the routing computer made a continual search for a significantly faster route. If a faster route was found, it was offered to the driver for acceptance or rejection. An OK New Route button on the steering wheel hub could be pressed to accept new routes. Traffic congestion and incidents were represented by icons on both the Guidance Display and Route Map screens. Synthesized voice announcement of traffic information could be activated or deactivated by a TRAFFIC REPORT button on the steering wheel hub. By default, the traffic report feature was off.

- **Location assistance for emergency services** — While the vehicle was in PARK, TravTek drivers could use the system to contact emergency services — either emergency road services from AAA, or 911 emergency services.

- **Other features** — A complete tutorial system was built into the TravTek in-vehicle system. Anytime the car was in PARK the driver could select tutorial instructions from the main menu. Most of the TravTek menu and information screens had a “HELP” key that, when touched, displayed a menu that offered screen-specific instructions. The HELP menu also provided access to a screen from which the system would dial the integrated cellular phone so that the driver could communicate with the TravTek help desk.

The Traffic Management Center

The TMC received traffic information from a number of sources, processed these data, and transmitted current traffic conditions to the TravTek vehicles. Data sources included the Florida Department of Transportation Freeway Management Center, Orlando’s traffic control system, a network of public and private sector reporting stations, and, most importantly, the TravTek vehicles. Information cleared through the system included link travel times, incident status, and the location of congestion. Link travel times were broadcast once each minute for any of 1,488 traffic links for which travel times were more than nominal.

The TravTek Information and Services Center

The AAA operated the TISC. The most visible function of the TISC was to provide help desk services to TravTek users. The TISC also provided and maintained the navigable map data base used in the vehicles. The data base represented a 3 100~km² area of metropolitan Orlando and consisted of approximately 74,000 navigable roadway links. The data base was updated and corrected at intervals throughout the operational test. The TISC also managed the local information directory data base.

TRAVTEK EVALUATION PLAN

The TravTek partnership viewed a comprehensive evaluation as an essential part of the TravTek Operational Test. Therefore, the partnership developed and implemented an evaluation plan aimed at recording performance measures for major components of the TravTek system. Data collection was built into TravTek’s three major components: the TMC, the TISC, and the vehicles.⁽¹⁾ Furthermore, separate, but integrated, studies were conducted that focused on issues such as driver satisfaction with TravTek features and functions, frequency of use of navigation displays, and the impact of real-time traffic updates on driver behavior and system performance.

Vehicle Configurations

In addition to providing extensive data collection capability, the partnership designed the system to serve as a research tool. The partners were particularly interested in the benefits of navigation assistance, route planning, route guidance, and real-time traffic information. To enable evaluation of these system benefits, the vehicles were designed to enable experimental comparisons. Three vehicle configurations were available: Services (S), Navigation (N), and Navigation Plus (N+). The S configuration provided an experimental control group for which all navigation, route planning, route guidance, and real-time information could be disabled. Thus the S (control) configuration provided access only to the Services and Attractions Directory features. The N configuration

provided a comparison group that had all the TravTek features except real-time traffic information. The N+ configuration provided all TravTek features. The capability to configure the vehicles in this way enabled the systematic evaluation of the effects of TravTek functions on elements of system performance such as driver performance, and network efficiency. Varying the configurations also enabled systematic evaluation of driver preferences. The three configurations are further described in the Methods section.

THE RENTAL USER STUDY AND THE LOCAL USER STUDY

The Rental User Study and the Local User Study were integral parts of the TravTek evaluation plan. These studies were designed to provide complimentary data on driver and system performance under naturalistic conditions. In the Rental User Study, drivers were mostly Orlando visitors and used TravTek on a short-term basis. In contrast, drivers in the Local User Study were Orlando residents and used TravTek over a 2-month period.

In these two studies, participants drove TravTek vehicles and responded to questionnaires and interviews. Data were captured at different points in time and from various sources. Rental User Study and Local User Study data sources included:

- Semi-structured debriefings of individual drivers.
- Driver interactions with the TravTek system electronically captured in an in-vehicle data log.
- Questionnaires.
- TISC reservation information.

PURPOSE OF STUDIES

The Rental User Study and Local User Study addressed four major issues:

1. Does TravTek affect driver performance, behavior, and satisfaction?
2. Which in-vehicle features do drivers prefer, and what is the frequency of use of those features?
3. How much do drivers report they are willing to pay for TravTek features and capabilities?
4. Does TravTek enhance trip and network efficiency?

Whereas both studies addressed the same issues, each provides a different perspective on those issues. Participants in the Rental User Study were primarily recruited from among individuals planning visits to the Orlando area. Rental users were expected to be relatively unfamiliar with the local area, and to drive with TravTek for a relatively short time. Thus the Rental User Study was intended to provide performance and preferences information from drivers unfamiliar with the local area, and who had limited experience with the TravTek system. Participants in the Local User Study were recruited from among local residents who were selected, in part, because they log above average mileage in the Orlando area. The Local User Study was intended to provide performance and preference information from drivers familiar with the local area. It was also in-

tended to suggest how extended experience with the TravTek system might affect driver performance and preference.

Besides the differences between users in the Rental User Study and Local User Study, the research designs differed with respect to the vehicle configurations that were used. The S configuration was intended to serve as a control configuration. It provided drivers with a data base of local services and attractions but did not provide navigation assistance, route planning, route guidance, or real-time traffic information. The N configuration provided the services and attraction data base, a moving map display, route planning, and route guidance, but not real-time traffic information. The N+ configuration provided all the navigation and routing features plus real-time traffic information and routing based on real-time information.

Both the Rental User Study and the Local User Study provided drivers with N and N+ configurations. Only the Rental User Study had a S configuration.

In the Rental User Study, each driver experienced only one vehicle configuration. Thus, in the Rental User Study there were three groups of users: S, N, and N+. To the extent feasible, drivers in the three groups were recruited and treated in a similar manner so that differences between the groups in performance and preference measures could reasonably be attributed to differences in the vehicle configurations they experienced.

In the Local Users Study, each driver experienced both the N and N+ configurations. Each Local User Study driver served as his or her own control. That is, for each local user, performance and preferences were assessed for a month of driving with the N configuration and a month of driving with the N+ configuration. To control for possible effects of the order of presentation of the two configurations, half the local users drove the N+ configuration during the first month of their participation and half drove the N configuration during the first month.

There was no S configuration in the Local Users Study. In part, the local users were not exposed to the S configuration due to resource constraints; requiring each driver to participate for an additional month with the S configuration would have reduced the number of drivers that could be tested during the 1-year operational test. Furthermore, the Services and Attractions Directory — the essential feature of the S configuration — was tailored for greatest utility to tourists. Therefore, for local users, the comparison of driving without TravTek to driving with TravTek's navigation and routing features was to the participants' experience when driving their own vehicles, rather than to driving a TravTek vehicle in the S configuration.

OBJECTIVES

One or more research objectives were associated with each of the four primary issues presented above. In this section, each objective is defined in terms of hypothesis, measures of effectiveness (MOE), measures of performance (MOP), data sources, and analysis techniques.

Does TravTek Affect Driver Performance, Behavior, and Satisfaction?

The objectives, hypotheses, measures of effectiveness, and data sources for assessing the effects of TravTek on driver performance, behavior, and satisfaction are summarized in table 1.

The use of the different vehicle configurations enabled evaluation of the effects of different types of in-vehicle information on driver perception of congestion, time savings, safety, system usability, and system learnability. As additional functions were added to S to provide the N configuration, and to N to provide N+, the level of complexity of the driver interface increased. Whereas the intent of the added functions was to make driving and navigation easier, quicker, and more satisfying, an inadequate interface could fall short of this intent. TravTek system designers' efforts to reduce the potential for user distraction, and to increase ease of use and ease of learning, are described by Fleischman, et al.⁽¹⁾ The objectives under this issue examine how well the designers achieved their goals with respect to driver performance, behavior, and satisfaction. With each added level of functionality it was expected that both driver performance and satisfaction would improve.

Participants in the Local User Study drove with TravTek for approximately 2 months: 1 month with the N configuration, and 1 month with the N+ configuration. If the use of TravTek functions changed over time, then these changes should have been observable in the in-vehicle log data. Data recorded in the log included all menu selections from touch screens, and all steering wheel button presses. The swap map button that toggled between the Guidance Display and Route Map was among the button press selections recorded. Selection of the Route Map and Guidance Display was of interest because researchers had earlier suggested that the information dense Route Map received longer duration glances than the Guidance Display. Those researchers suggested that inexperience with the Route Map might account, in part, for these longer glances.⁽⁵⁾ The TravTek Camera Car Study examined glance times directly, and 12 Local User Study participants were observed in the Camera Car Study.⁽⁶⁾ In the Camera Car Study, local users were observed twice, once before they had any other TravTek experience, and again after driving with TravTek for about 4 weeks. Glance times were not observed in either the Rental User Study or the Local User Study. However, the amount of time users had the Route Map and Guidance Display selected was recorded, and these findings are reported here. The Camera Car Study results obtained from Local User Study participants showed that duration and frequency of glances to the TravTek displays decrease with experience. The Local User Study enabled characterization of the pattern of use of the displays that presumably led to the change in glance patterns. The Camera Car Study includes a report of daily display use for the 12 local users who participated in that study. In this report, usage data for all Local User Study participants are reported.

Table 1. Does TravTek affect driver performance, behavior, and satisfaction?

Objectives	Hypothesis	Measures of Effectiveness	Measures of Performance	Data Source
Assess the effects of TravTek configurations on driving and navigation performance.	Perceptions of driving and navigation behavior varies as a function of vehicle configuration.	<ul style="list-style-type: none"> . Driving performance. . Navigation performance. 	Driver perceptions of: <ul style="list-style-type: none"> . Way-finding. . Travel time. . Trip generation. . Driving safety. . Driving workload. 	<ul style="list-style-type: none"> . Questionnaire.
Assess the effects of TravTek configurations on driver satisfaction and TravTek usage.	Driver satisfaction varies as a function of vehicle configuration.	<ul style="list-style-type: none"> . Congestion avoidance. . Safety. . Stated satisfaction. . Use of drive functions. 	<ul style="list-style-type: none"> . Driver perceptions of time saving. . Driver perception of security. . Driver statements of satisfaction with Trav Tek system and its Components. . Percent of use (time, frequency) of drive functions. 	<ul style="list-style-type: none"> . Questionnaire. . In-vehicle log.
Assess system usability and learnability.	TravTek is easy to use to learn, and the drivers will show evidence of learning over the duration of the study.	<ul style="list-style-type: none"> . System usability. . System learnability. . Changes in usage patterns over time. 	<ul style="list-style-type: none"> . Perceptions of usability. . Perceptions of learnability. . Use of navigation and route guidance functions over time. 	<ul style="list-style-type: none"> . Questionnaire. . In-vehicle log.

Which In-vehicle Features do Drivers Prefer and What is the Frequency of Use of Features?

The objectives, hypotheses, measures of effectiveness, and data sources for assessing which features drivers prefer, and the frequency of use of those features, are summarized in table 2.

Separate presentation of user preferences from user performance and behavior is problematic. For instance, observations of the frequency and duration of drivers' use the Guidance Display and Route Map are performance measures that are potentially closely related to driving performance. However, frequency and duration of use also be indications of user preference. In preparation of this report, preferences for, and use of, TravTek features that were available while driving were organized under the driving performance and frequency use for functions not available while driving are discussed separately.

Drivers' ratings of TravTek features were obtained in questionnaires. Renters were given a questionnaire tailored to the vehicle configuration they drove. The questionnaire was administered when they returned their TravTek vehicle to Avis Rental Car, Inc. at the end of their visit. Local users were given two nearly identical questionnaires; one when they completed driving the N+ configuration and one when they completed driving the N configuration. Many renters, and all local users, were debriefed in an interview format. The debriefings provided a rich data base of comments on TravTek features that aided in interpretation of ratings and feature usage findings.

Table 2. Which in-vehicle features do drivers prefer and what is the frequency of use of each feature.

Objectives	Hypothesis	Measures of Effectiveness	Measures of Performance	Data Source
Assess driver' stated preference for TravTek pre-drive TravTek features.	Drivers will prefer some displays and controls over others.	. Subjective ratings.	. Subjective ratings of selected features and functions.	. Questionnaire. . Debriefings.
Assess drivers' frequency of use of predrive TravTek features.	Frequency of use of features will vary as a function of experience with TravTek.	. Frequency of feature use.	. Frequency of button presses for selected features and functions. . Frequency of button presses over time.	. In-vehicle log.

How Much Do Drivers Report They are Willing to Pay for TravTek Features and Capabilities?

The objectives, hypotheses, measures of effectiveness, and data sources for assessing the amount drivers are willing to pay for TravTek-like systems are summarized in table 3.

Regardless of how many benefits might be derived from wide-spread implementation of TravTek-like systems, the potential of such systems will rely, to a great extent, on whether individuals are willing to pay for individual TravTek features, purchased separately, as well as for the TravTek system as they experienced it. The findings suggest how much individuals would actually pay for TravTek features, and may also suggest a relative ranking of consumer demand for the various features. Furthermore, because the demographics of the rental user and local user populations were different, the findings may suggest potential user acceptance across a wide spectrum of potential purchasers.

Table 3. How much do drivers report they are willing to pay for TravTek features and capabilities?

Objectives	Hypothesis	Measures of Effectiveness	Measures of Performance	Data Source
Assess drivers willingness to pay for TravTek features and functions.	. Willingness to pay will increase as capabilities are increased. . Willingness to pay will be affected by demographic variables, such as: income level and age.	. Willingness to pay.	Subjective ratings of Willingness to pay for: . Individual TravTek features. . The TravTek system as experienced. . In new, existing and rental vehicles.	. Questionnaire.

Does TravTek Enhance Trip and Network Efficiency?

The objectives, hypotheses, measures of effectiveness and data sources for assessment of trip and network efficiency are summarized in table 4.

The different levels of in-vehicle information presented to rental and local users provided the means to compare configurations in terms of congestion avoidance, time savings, and vehicle operating costs. The two studies relied primarily on questionnaire responses to evaluate the trip and network efficiency objectives. Because of the naturalistic conditions under which the field data were collected, the studies were best suited to yield data concerning users' perceptions of trip and network efficiency.

Other TravTek studies were specifically designed to address trip efficiency questions with data other than user perceptions. In particular, the Yoked Driver Study deployed drivers in each of the three configurations to drive from common origins to common destinations at 2-minute intervals.⁽⁷⁾ This procedure enabled collection of performance data from each of the configurations under the same traffic conditions- a result that would not be feasible in a naturalistic study. In the Yoked Driver Study, observers who were part of the evaluation accompanied drivers on these trips and recorded additional measures of performance. The TravTek Evaluation Modeling Study used data, primarily from the Yoked Drivers Study and the Camera Car Study, to project the effects of individual TravTek driver behavior on network trip efficiency.⁽⁸⁾ That is, the Modeling Study projected the effects of TravTek for both users and non-users of TravTek. It simulated a network where TravTek was deployed at various levels of market penetration. Other TravTek study results are discussed in this report where they may enhance the findings obtained from questionnaire and debriefing responses of the rental and local users.

Table 4. Does TravTek enhance trip and network efficiency?

Objectives	Hypothesis	Measures of Effectiveness	Measures of Performance	Data Source
Assess the effect of TravTek on congestion avoidance.	Congestion avoidance varies as a function of vehicle configuration.	. Congestion avoidance.	. Driver perception of congestion avoidance.	. Questionnaire.
Assess the effect of TravTek on time saving.	Trip time savings varies as a function of vehicle configuration.	. Time savings.	. Driver perception of time savings.	. Questionnaire.
Assess the effect of TravTek on vehicle operating cost.	Vehicle operation cost varies as a function of vehicle configuration.	. Vehicle operation cost.	. Driver perception of fuel savings.	. Questionnaire.

Congestion Avoidance. Drivers in the present studies were asked whether they perceived that TravTek helped them avoid congestion. Because the N+ configuration used real-time information, it was anticipated that users in that configuration would more strongly agree that TravTek helped them avoid congestion would more strongly agree that TravTek helped them avoid congestion. It was not assumed that drivers, particularly visitors, could detect whether they were actually avoiding congestion, rather the objective was to assess drivers' perceptions, if any, concerning congestion avoidance.

Travel Time Savings. It was hypothesized that trips which avoided congestion would have shorter travel times. Drivers in the present studies were asked whether they perceived that TravTek helped them save time. Because the N+ configuration used real-time information, it was anticipated that users in that configuration would strongly agree that TravTek helped them save more time than would N or S drivers. Because TravTek provided guidance to unfamiliar destinations, it was anticipated that N and N+ users would perceive TravTek to

save more time than would S configuration drivers.

Operating Cost. It was hypothesized that real-time traffic information would result in faster trips and more constant speeds because it helped drivers avoid congestion. Such a result should save fuel. Therefore, in addition to being asked whether they perceived TravTek to save time, drivers were asked whether they perceived a fuel savings. Because the N+ configuration used real-time information, it was anticipated that users in that configuration would strongly agree that TravTek helped them save more fuel than would N or S drivers.

As with congestion avoidance, participants in these studies could not have objectively assessed travel time savings or operating cost benefits. However, it may be worth noting whether there were a perceptions of benefit, and these were objectives of this study.

METHODS

This section describes the test procedures and conditions for the Rental User Study and the Local User Study.

TEST CONFIGURATIONS

Of 100 vehicles in the TravTek Operational Test, 75 were part of the Avis rental fleet and used by participants in the Rental User Study. Another 23 vehicles were available for other TravTek studies, one of which was the Local User Study. Two vehicles were reserved for Partner use that included rental user recruitment and technology demonstrations. A key feature of the TravTek system that made it ideal for conducting ATIS research was the ability to control the ATIS options that were available to drivers. This feature was critical to the research design of both the Rental User Study and the Local User Study. Three configurations were used in the Rental User Study: S, N and N+. Two configurations were used for the Local User Study: N and N+. Drivers in the Rental User Study were assigned to one of the three configurations by AAA, and Avis Rental Car, Inc. representatives configured the rental vehicles appropriately. Each local user drove both the N and N+ configurations for 1 month each, and the test evaluator determined the order in which the configurations were assigned. The configurations are described in the following paragraphs.

Services (S)

This configuration was included primarily to serve as a baseline, or control configuration against which results obtained with the other vehicle configurations could be compared. The S configuration provided drivers with access to the local information data base, emergency service functions, and the integrated cellular phone. The local information data base of services and attractions included information on restaurants, hotels, entertainment, local attractions, and other businesses and services that might be of special interest to visitors. Once a user selected a particular service or attraction, a map showing the location of the selection could be displayed. The integrated cellular phone could be activated from a soft key on the video display so that the user could call the associated phone number without having to key in digits. S functions were only available when the vehicle was in PARR. The map in this configuration did not indicate the position of the vehicle, as position information was considered a navigation feature and therefore was inconsistent with the S configuration serving as a control.

Navigation (N)

The N configuration provided all the functions available in the S configuration and, additionally, included vehicle position, route planning, and route guidance functions. Routes could be planned according to any of three user selectable criteria: fastest, avoid tolls, and avoid Interstates. Given these criteria, routes planned by the system minimized travel time. Travel time estimates for trips were based on nominal link travel times. That is, N configuration travel times were based primarily on the speed limits associated with the road class of links in an in-vehicle data base.

Navigation Plus (N+)

The N+ configuration had all the functions available in the N and S configurations plus the availability of real-time traffic information. The real-time information was integrated into the navigation, route planning, and route guidance functions. Only in the N+ configuration were traffic incidents indicated on the navigation displays. Only in the N+ configuration could the driver obtain synthesized voice reports of traffic conditions by pressing a button on the steering wheel hub. Only in the N+ configuration were routes planned that took into account historical and real-time travel times for the 1,488 traffic links monitored by the TravTek system.

TEST CONDITIONS

In this section the TravTek Traffic Network, the driver sampling populations and the period of performance for the tests are described.

The TravTek Traffic Network

The area represented by the TravTek traffic network encompassed approximately 3 100 km² and included approximately 16 000 km of navigable roadway. A shaded line indicates coverage area boundaries in figure 5. The TravTek system could plan trips and provide guidance for any destination within the coverage area, provided that no portion of the trip fell outside the area. Real-time traffic information was available for 1,488 traffic links that represented a total distance of 1854 km. Traffic link distance is directional, so the amount of navigable roadways covered by TravTek traffic links was roughly half of the total link distance, or about 925 km. The information broadcast to the vehicles was real-time in that updates were broadcast every minute. The link travel time information was from sources that included: loop-detectors on the Interstate; traffic control signal loop-detectors on some arterials in the City of Orlando, historical travel times, and probe reports from TravTek vehicles. The historical travel time data base provided link travel time estimates that varied with time-of-day and day-of-week. Software continually refined historical travel times based on information from other TravTek link travel time data sources. The TravTek System Architecture Evaluation report provides further description of the TravTek Traffic Network.⁽⁹⁾ The network description provided here is intended to provide a perspective for the distinction between N and N+ vehicle configurations.

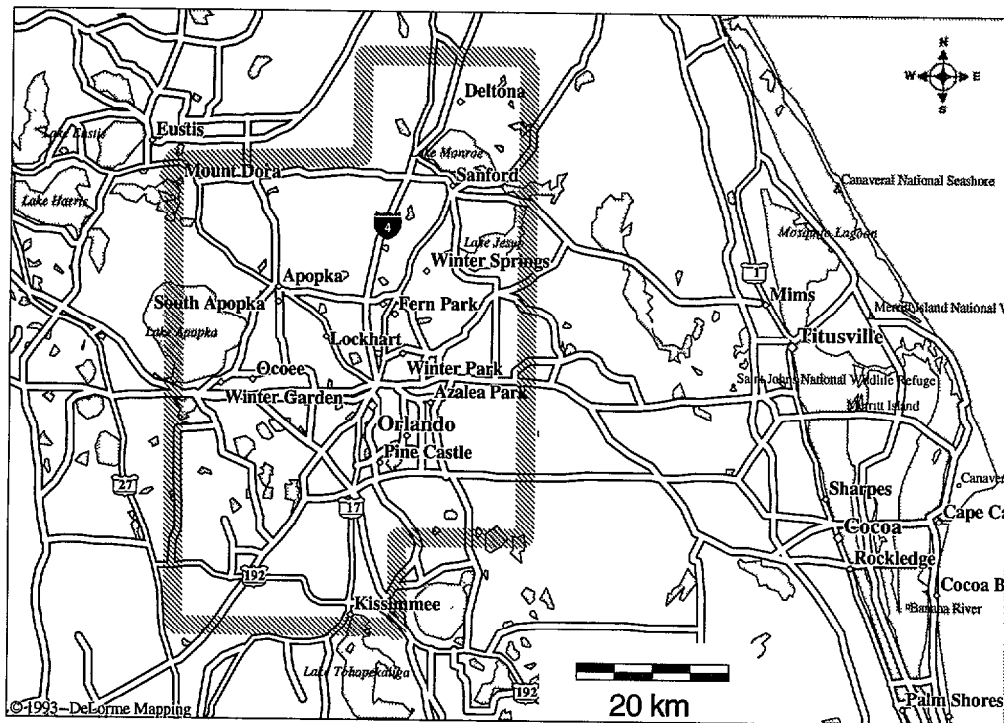


Figure 5. The TravTek coverage area extended beyond Deltona on the North; Winter Springs on the East; Orlando International Airport, Kissimmee and Walt Disney World on the South; and Winter Garden on the West.

TravTek Drivers

The two studies described in this report are based on two contrasting samples of drivers. The Rental User Study drivers were primarily visitors to Orlando who were somewhat unfamiliar with the local area and who drove the TravTek vehicles for an average of 4 to 6 days. The Local User Study drivers were residents of Orlando who were chosen in part because they frequently drove within the network and were familiar with the area.

Rental User Study. The participants in this study were recruited by AAA, with support from Avis Rental Car, Inc., and the TravTek partners. The minimum requirements for participation were those required of all Avis rental customers: a valid drivers license and a minimum age of 25 years. The rental agency charge for a TravTek vehicle was \$29 per day. This charge was less than the standard airport rental charge through most of the study period.

AAA recruited members from regional affiliates across the United States. The recruitment plan assigned each AAA State affiliate to one of the three vehicle configurations so that drivers from a region would all experience the same TravTek features. AAA clubs were assigned configurations such that each major geographical segment of the United States was represented in each configuration. In assigning drivers by State, AAA intended to minimize the possibility that members from the same State would be disappointed if they received a less capable vehicle than an acquaintance. However, publicity about TravTek led some drivers who were scheduled for the S configuration to expect a vehicle with voice guidance and route planning. When drivers assigned to S voiced disappointment based on this expectation, they were upgraded to N or (more frequently) the N+

configuration. Whereas this upgrade was necessary to keep these drivers in the study, and to protect Avis Rental Car, Inc. and AAA from negative customer reactions, it does potentially compromise the S configuration as a baseline or control. Drivers who insisted on an upgrade may have evaluated the S configuration, or the configuration they received, differently than drivers who did not speak out. The necessity to upgrade participants at their request also resulted in a disproportionate number of drivers in the N+ and N configurations.

In addition to recruitment from among their membership, AAA also recruited from organizations planning conventions in Orlando. The Chamber of Commerce provided lists of upcoming conventions and AAA solicited interest from convention organizers to promote TravTek participation among convention attendees. Avis Rental Car, Inc. also assisted in recruitment, through promotional contests among employees at Avis rental desks at Orlando International Airport. Drivers recruited by Avis were randomly assigned to one of the three vehicle configurations.

According to the AAA reservation system records, there were 2,896 TravTek vehicle rentals, to 4,354 drivers. Employees of TravTek Partner organizations, Partner affiliates, or others with special TravTek interests have been excluded from the analyses reported in this report. After exclusion of these VIP's, there were a total of 2,568 rentals with 3,944 drivers in the reservation system records. Of these qualified drivers in the reservation system, 1,332 (34 percent) were female and 2,612 (66 percent) were male. Couples renting vehicles were asked to classify themselves as primary driver and secondary driver. Questionnaire results are presented only for primary drivers. Of the primary drivers in the reservation system, 1,278 (50 percent) were assigned to the N+ configuration, 921 (36 percent) to the N configuration, and 369 (14 percent) to the S configuration. The majority of all rental reservations, 81 percent, were made through AAA with the remaining 19 percent recruited at the Avis counter. For the purposes of the evaluation, drivers were classified into three age groups: 25 through 34, 35 through 54, and 55 and older. The percentage of drivers in each age group was 19, 64, and 17 respectively and was essentially the same across vehicle configurations ($\chi^2(4) = 1.05$).

The reservation system summary data provide a valid picture of the driver population from which the data in this report were drawn. However, they do not necessarily provide an accurate description of the demographics for any particular analysis. Some questionnaire and in-vehicle log data analyzed for this report came from drivers who were not in the AAA reservation system, and not all drivers recorded in the reservation system turned in questionnaires. Furthermore, usable in-vehicle log data were obtained for only about two-thirds of the rentals.

Whereas drivers recruited through conventions tended to be business travelers, drivers recruited through AAA affiliates were more likely to be traveling for pleasure. Exceptionally strong recruitment efforts by AAA affiliates assigned to the N configuration resulted in a greater proportion of the N configuration drivers falling into the pleasure travel category. Because the purpose of visits was correlated with the length of visits, the average visit length was not equal across vehicle configurations. Business travelers averaged 4 rental days compared to 7 and 6.1 days for pleasure and combined business and pleasure travelers respectively. N+ rentals averaged 5.2 days, N rentals averaged 6.1 days, and Service rentals averaged 5.3 days. The difference in average trip length between configurations was statistically reliable ($F(2, 2565) = 21.03, p < 0.001$).

Table 5. The percent of rental drivers in each vehicle configuration as a function of trip purpose.

<i>Purpose of Trip</i>	<i>Vehicle Configuration</i>		
	<i>N+</i>	<i>N</i>	<i>S</i>
Business	51	35	38
Pleasure	36	50	43
Business and Pleasure	13	15	19

Local User Study. Recruitment for the Local User Study was performed by the evaluation contractor. Recruitment focused on local drivers who traveled 64 km or more per day within the network area. An effort was made to recruit equal numbers of males and females and to include drivers whose ages spanned the age range for eligible drivers. The minimum requirement for drivers was the same as that for the Rental User Study: a valid drivers license and a minimum age of 25 years. Local User Study participants also had to meet insurance company requirements that precluded participation if they had a combination of more than two moving violations or reportable accidents in the previous 3 years. Local User participants were given use of the vehicle free of charges except for fuel.

Table 6 shows the sample size, gender and age statistics for the 51 participants in the Local User Study.

Table 6. Age and gender demographics of Local User Study participants.

<i>Age Group</i>	<i>Males</i>				<i>Females</i>			
	<i>N</i>	<i>Mean</i>	<i>Min</i>	<i>Max</i>	<i>N</i>	<i>Mean</i>	<i>Min</i>	<i>Max</i>
25 - 34	8	28.8	25	34	6	29.2	26	34
35 - 54	17	41.2	36	51	8	41.9	35	52
55andover	7	69.0	64	77	5	65.4	56	71

Local User Study participants drove the TravTek vehicle for approximately 2 months. Approximately half the users drove the N+ configuration during the first month and were switched to the N configuration for the second month, whereas the other half of the users drove the N configuration first and the N+ configuration last. The users were given a questionnaire at the end of their experience with each configuration. The questionnaires were identical except that the N+ questionnaire included additional questions concerning real-time traffic information.

Period of Performance

The Rental User Study was conducted between March 31, 1992 and March 31, 1993. Recruitment activities preceded the start of operations by several months and collection of questionnaires continued for several weeks after the end of operations. No vehicles were rented after March 20, 1993.

The Local User Study began in June of 1992 and continued through March of 1993.

Materials and Instrumentation

In this section the data sources for the two studies are described. These data sources were: questionnaires, debriefings, and in-vehicle logs.

Questionnaires. Questionnaires were given to the renters when they returned their TravTek vehicle to Avis Rental Car, Inc. A postage-paid return envelope accompanied the questionnaire. The same basic questionnaire format was used for all participants in both studies. The basic questionnaire was tailored for drivers in each vehicle configuration. Questions specific to features available only with a configuration the driver did not experience were excluded. For instance, N configuration drivers were not asked to judge the accuracy of real-time traffic information, and S configuration drivers were not asked whether the Guidance Display helped them find their way. Drivers in all configurations were asked to respond to general statements about the system such as “the TravTek system helped me avoid congestion” or “the TravTek system helped me find my way” even when their configuration might not be expected to confer a benefit because it lacked a specific feature. The Rental User Study questionnaire was revised twice during the course of the study. The changes were minor and are described in the results section with the presentation of the respective findings to which the changes applied.

In part because of last minute changes in vehicle mode at the renter’s request, and in part because of clerical errors that occurred when the rental vehicles were returned, not all renters received the questionnaire appropriate to the configuration they had experienced. To ensure that ratings from respondents answering inappropriate questions did not distort the results, a number of precautions were taken. First, whenever possible the configuration indicated by the questionnaire was checked against the in-vehicle log. Because the in-vehicle log recorded the mode the vehicle was actually in, it was regarded as the best source for configuration verification. When a renter’s in-vehicle log was not available, the mode indicated by the questionnaires was checked against the mode indicated by the AAA reservation desk. In cases where a renter with the S configuration was given a N or N+ questionnaire, the renter’s data were excluded from further analyses. In cases where a N or N+ configuration renter was given a S questionnaire, only questions common to all three questionnaires were analyzed. In cases where a N configuration driver received a N+ configuration questionnaire, responses to N+ specific questions were excluded from analyses. All responses from N+ configuration drivers were included in analyses, as there were no differences between N+ and N questionnaires except for the omission of real-time traffic information related questions from the N questionnaire.

The return rate for the questionnaires was quite high. A total of 1,733 questionnaires were returned by non-VIP renters. The number returned and the percent of questionnaires returned are shown as a function of vehicle configuration in table 7. The return rate is approximate because the exact number of renters who received questionnaires is unknown. The percentage shown in the table is based on the assumption that questionnaires were given to all renters listed in the AAA reservation system. The actual number of renters receiving questionnaires may have been higher because the reservation system missed a small percentage of renters, or lower because some renters failed to receive a questionnaire. Table 8 shows the age group and gender distribution for questionnaire respondents who provided that information (only 1,298 of the 1,733 respondents identified their gender). Although the youngest age group was nominally 25 to 34, because of

Avis Rental Car, Inc. age restrictions, there were a few business rentals to drivers as young as 21 years of age who obtained underwriting from their employers. The number of male respondents far exceeded the number of female respondents. This resulted, in part, because for couples traveling together the male most often listed himself as the primary driver responses are reported here. Although the questionnaires included provision of responses from a secondary driver, these responses are not reported because they were nearly identical to the primary driver responses and did not appear to provide independent perceptions of the TravTek system.

Table 7. Questionnaires returned by Rental User Study participants shown as a function of vehicle configuration.

<i>Configuration</i>	<i>Number Returned</i>	<i>Approximate Return Rate</i>
S	154	42 Percent
N	644	70 Percent
N+	915	73 Percent

Table 8. Age group and gender breakdown for Rental User Study questionnaire respondents.

<i>Age Group</i>	<i>Gender</i>	<i>N+</i>	<i>N</i>	<i>S</i>	<i>Total</i>
25 to 34	Females	24	13	3	40
	Males	83	55	21	159
	<i>Subtotal</i>	107	68	24	199
35 to 54	Females	52	44	17	113
	Males	383	289	66	738
	<i>Subtotal</i>	435	333	83	851
55 and over	Females	9	6	4	19
	Males	116	88	25	229
	<i>Subtotal</i>	125	94	29	248
	Total				1,298

The Local User Study participants completed two questionnaires, one at the end of their first month of participation and one at the end of the second month. The two questionnaires differed only with respect to questions about perceptions of TravTek's real-time travel information. Additional questions concerning real-time information were included in the period following the local users' N+ exposure.

Debriefs. In addition to formal questionnaires, drivers in both the Rental User Study and Local User Study were asked to participate in a semi-structured debriefing in which they were free to say whatever they wanted about the TravTek system. Whereas drivers were free to say whatever they wanted, the following questions were always asked to elicit open ended responses:

- Overall, what impressions do you have about TravTek now that you've had a chance to "drive the future?"
- What was your favorite feature?
- What was your least favorite feature?
- While driving with TravTek, were there any situations where TravTek was especially helpful?
- While driving with TravTek, were there any situations where TravTek was not helpful?
- Did the orientation you were given prepare you for driving with TravTek?
- Can you think of anything that could be improved about TravTek to make it better?

Renters were debriefed at the Orlando International Airport at the time they were scheduled to depart. Because of the large number of renters, and the fact that they could return the vehicles at all hours, and because not all renters departed at the scheduled time, it was never intended that all renters be debriefed. However, 486 of the renters were debriefed: 42 from the S configuration, 216 from the N configuration, and 228 from the N+ configuration.

Local User Study drivers were debriefed at the end of their first week of participation.

In-Vehicle Logs. One of two TravTek onboard computers was used to record performance data. This in-vehicle log recorded events with time and date stamps for all driver interaction with the TravTek interface. Thus every button press, whether on the steering wheel hub or on the TravTek touch screen, was recorded. Much data were recorded in this log and the current description is not intended to be exhaustive. Other in-vehicle log data included:

- All messages received from the TMC.
- The identity and travel time for every TravTek traffic link that was traversed.
- Latitudes and longitudes from both the Global Positioning System and the dead reckoning/map matching system (every 15 seconds).
- Vehicle speed once per second.
- All synthetic voice messages that were generated.
- All Guidance Display text messages that alerted the driver to upcoming maneuvers or off-route status.
- The start and end times for each trip and trip distance (regardless of whether the TravTek system was accessed).

The in-vehicle log database provided a rich source of information about how, when, and where users traveled. This report focuses on a select subset of that data that addresses the issues set forth in the introduction.

In-vehicle logs were downloaded from a computer in the vehicle to a vehicle maintenance station (VMS) computer located at the Avis service area at Orlando International Airport. From the VMS, data were transferred via magnetic media to General Motors Research in Warren, Michigan. General Motors Research decoded the in-vehicle data and made it available to the evaluators.

Because of the nature of magnetic storage, and the relatively rugged environment in-vehicle storage represented, some data were lost during storage or transfer. Approximately two-thirds of all rental and local user trips were available for analysis. All rental user data except that from VIP's were included in in-vehicle log analysis.

Table 9 shows the age and gender of primary drivers of the vehicles included in the in-vehicle log analyses. The demographic data included in table 9 were derived from TISC reservation system logs.

Table 9. Age and gender of primary drivers of vehicles that contributed to in-vehicle log data analyses.

<i>Age Group</i>	<i>Gender</i>	<i>N+</i>	<i>N</i>	<i>S</i>	<i>Total</i>
25 to 34	Females	21	30	7	58
	Males	91	51	31	173
	<i>Subtotal</i>	<i>112</i>	<i>81</i>	<i>38</i>	<i>231</i>
35 to 54	Females	53	52	14	119
	Males	332	267	92	691
	<i>Subtotal</i>	<i>385</i>	<i>319</i>	<i>106</i>	<i>810</i>
55 and over	Females	14	13	8	35
	Males	110	83	55	248
	<i>Subtotal</i>	<i>124</i>	<i>96</i>	<i>63</i>	<i>283</i>
	Total	621	496	207	1,324

TISC Logs. The TravTek Information and Services Center data logs included the AAA reservation system, a map data base, a help desk log, a mid-rental interview log, and selected information about TravTek vehicles that was obtained through an electronic link to the TMC. This report utilized the reservation system log to obtain demographic summary data on rental users.

Research Design

The Rental User Study was a naturalistic field study in which TravTek system users were observed with three vehicle configurations: S, N, and N+. A three factor between groups design was used such that each driver was observed with only one of the three vehicle configurations. Assignment to configurations was not biased in a way that it should have influenced the findings. One exception to the assignment procedure that was not anticipated in the design of the research was that drivers could request to be given a configuration other than that to which they were assigned. This exception may have influenced the results, but the nature of this influence cannot be assessed with the available data.

The Local User Study was a naturalistic field study in which TravTek system users were observed with two vehicle configurations: N and N+. A two factor repeated-measures design was used such that all drivers were observed with both configurations. Assignment to the order in which the configurations were experienced was random with the constraint that approximately equal numbers of male and female users from each age

group experience each configuration first. The users in this study were long-time Orlando area.

RESULTS

Four issues were presented in the introduction:

1. Does TravTek affect driver performance, behavior, and satisfaction?
2. What in-vehicle features do drivers prefer and what is the frequency of use of each feature?
3. How much do drivers report they are willing to pay for TravTek features and capabilities?
4. Does TravTek enhance trip and network efficiency?

The issue orientation is maintained in presentation of Rental User Study and Local User Study findings.

Does TravTek Affect Driver Performance, Behavior and Satisfaction?

This section examines actual and perceived driver performance, behavior, and satisfaction with TravTek functions that were available while the vehicle was in gear, i.e., performance and perceptions of performance with respect to functions that could be accessed while driving.

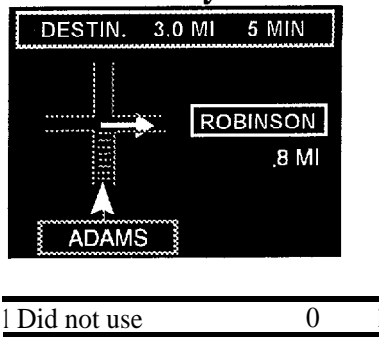
Five aspects of perception of the effects of the TravTek system on navigation and driving performances are examined. These are perceptions of effects on:

- Way-finding.
- Travel time.
- Trip generation.
- Safety.
- Interference with, and Attention to, driving.

The data on perceptions of effects on driving and navigation performance are from the questionnaires. For most questions, the respondent was to circle the integer value that best represented his or her perception. The integers ranged from one to six, where one was labeled “strongly disagree” and six was labeled “strongly agree.” Figure 6 depicts a typical questionnaire item. As in this example, most questionnaire items were accompanied by a graphic representation of the system component that was the subject of the item.

The questionnaires were screened against in-vehicle logs and other available data to ensure that the users were exposed to the vehicle configuration for which the questionnaire they filled out was designed. The most serious problem was that some respondents with S configured vehicles received N+ configuration questionnaires. For all the analyses that follow, respondents from S configuration who received the wrong questionnaire were excluded. Thus for most analyses there were 829 N+ configuration respondents, 644 N configuration respondents, and 154 S configuration respondents. The N+ and N questionnaires differed only with respect to questions about traffic information, and thus required screening only for questions that concerned traffic information.

The TravTek System's Guidance Display:



	Strongly Disagree			Strongly Agree		
Was Easy to Learn	1	2	3	4	5	6
Was Easy to Use	1	2	3	4	5	6
Helped Me Find My Way	1	2	3	4	5	6
Helped Me Pay More Attention To My Driving	1	2	3	4	5	6
Interfered with My Driving	1	2	3	4	5	6
Provided Timely Information	1	2	3	4	5	6

Figure 6. This question is typical of the format of items in the TravTek Rental User Study and Local User Study questionnaires.

Way-finding. Overall, both renters and local users rated the TravTek system very favorably with respect to way-finding. Mean agreement of the three renter configuration groups to the item “Overall, the TravTek system helped me find my way” are shown in table 10. The ratings of N+ and N users were not significantly different ($p > 0.05$) from each other, as would be expected because real-time information was not intended to impact way-finding. The rating of S configuration drivers is not significantly different from 3.5, which is the neutral point — neither agreeing nor disagreeing with the assertion that the system helped them find their way. A neutral rating is consistent with what might be expected as the S configuration did not offer way-finding assistance beyond the availability the TISC help desk.

Table 10. Mean rental user ratings of TravTek systems’ helpfulness for way-finding.

	N+	N	S
Mean	5.4	5.3	3.4
N	913	624	135

Although TravTek has been empirically demonstrated to improve way-finding, it is still important, if TravTek-like systems are to succeed in the marketplace, that users perceive this benefit. Other TravTek studies empirically demonstrated that way-finding with TravTek is superior to way-finding without it. For instance, in the Orlando Test Network Study, drivers that used TravTek saved more than 5 min in trip planning time, more than 4 min in travel time, spent less time off route, and more quickly recognized wrong turns than the same drivers when planned and navigated without TravTek.⁽¹⁰⁾ In that study drivers planned routes, and drove, from prescribed origins to prescribed destinations either by using TravTek to plan the route and guide them, or by planning and following a route “as they normally would.” The drivers were visitors to the Orlando area, and the origins and destinations were in residential neighborhoods approximately 16.1 km apart. All drivers who used TravTek with visual displays and voice supplement arrived at their destinations, whereas 7 percent of drivers in the control (no TravTek) condition failed to complete their trips. Findings from the Yoked Driver Study and Camera Car Study were similar.^(6,7)

Renters. Table 11 lists the questionnaire items that were related to the perception of the effects of TravTek features or functions on way-finding performance. For all items shown, the respondent indicated agreement or disagreement with the assertion that a feature or function “helped me find my way.” Shown are means, lower and upper 95 percent confidence limits (LCL and UCL respectively), the number of respondents who indicated a level of agreement (N), the number of questionnaire respondents who did not respond to the subject question, and the number of individuals who declined to rate a feature because they said they did not use it.

Real-time information was not expected to affect the effectiveness of TravTek route guidance features, and no differences in N and N+ drivers’ assessments of way-finding were found. Therefore, data shown in table 11 combine responses from N and N+ rental drivers. S configuration drivers were not asked to respond to these items, except for the first item for which results are shown in table 10, above.

The lower and upper confidence limits shown in table 11 to provide a means of judging the reliability of the findings. Confidence intervals can be interpreted as the bounds within which, if the survey were repeated a large number of times, approximately 95 times out of 100 the mean would fall within this range. The confidence limits are based on the assumption that the data are sampled from a population in which the ratings are normally distributed. When the mean ratings approach the ends of the population distribution (one or six in this survey) the data are rarely normally distributed. However, in the case of samples as large as those in this survey, the violation of the normality assumption is not of practical concern unless one is interested in very small differences between means that are close to the ends of the range. In general, if the upper and lower bounds of items do not overlap, the difference between the means of those items is statistically reliable. However, it was generally not our intent to examine differences between means. Rather, in most instances, our interest was in whether respondents agreed or disagreed with the item assertions. A rating of 3.5 would be neutral — the midpoint between “strongly disagree” and “strongly agree.” If the confidence limits do not include 3.5, then the mean ratings are significantly different from neutral.

Most, but not all, questions offered “did not use” as an alternative. This alternative was not available for questions where it was assumed that all respondents had relevant experience, e.g., the overall TravTek system. The data shown in table 11 are from 1,577 N and N+ respondents who returned questionnaires.

The format of most questionnaire items was the same. That is, for each area of perception queried (e.g., way-finding, travel time savings, safety), ratings were requested for a common set of features:

- The overall system.
- The visual displays:
 - Guidance Display.
 - Route Map.
 - Navigation Display (map with no planned route).
- The Voice Guide.

- The zoom-in, zoom-out function.
- The steering wheel button functions:
 - Swap Map.
 - OK New Route.
 - Where Am I.
 - Repeat Voice.
 - Hop Right/Left.

This order of presentation of results will be followed throughout this section, with some variation as there were minor variations in question content.

Table 11. Rental users' perceptions of TravTek's ability to help them find their way.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>	<i>NO Response</i>	<i>Did Not Use</i>
Overall, the TravTek system	5.3	5.28	5.37	1537	40	na*
The TravTek system's Guidance Display	5.2	5.20	5.31	1498	45	34
The TravTek system's Route Map	5.1	5.06	5.17	1488	50	39
The TravTek system's Voice Guide Feature ("Turn right on Robinson" button located on steering wheel)	5.3	5.22	5.33	1390	58	129
The TravTek system's technique of displaying a local map for driving without a destination	5.1	5.05	5.18	1183	55	339
The TravTek system's Zoom In/Zoom Out Feature	4.8	4.75	4.89	1368	57	152
Overall, the steering wheel buttons	4.9	4.83	4.95	1492	85	na*
The TravTek system's SWAP MAP feature	5.1	5.00	5.15	1061	60	456
The TravTek system's OK NEW ROUTE feature (located on the steering wheel)	5.0	4.95	5.05	1319	67	191
The TravTek system's WHERE AM I feature ("Heading west on Colonial"; Button located on steering wheel)	4.7	4.59	4.75	1246	62	269
The TravTek system's REPEAT VOICE feature ("The last message was.. ..." button located on steering wheel")	4.6	4.51	4.67	1110	65	402
The TravTek system's Hop Right/Hop Left feature (located on the steering wheel)	4.0	3.95	4.14	814	105	658

* "na" indicates that 'Did not use' was not an available response.

Overall, respondents with N+ and N configurations rated the TravTek system favorably with respect to way-finding. The two visual displays, the Guidance Display and the Route Map, and the Voice Guide were very favorably rated. The individual steering wheel button functions were also rated as helpful to way-finding, although not as strongly as for the features that specifically focused on route guidance.

Three N+ configuration specific questions examined way-finding effects:

- “The TravTek system’s technique of displaying updated traffic information on the Guidance Display helped me find my way.”
- “The TravTek system’s technique of displaying updated traffic information on the Route Map helped me find my way.”
- “The TravTek system’s Traffic Report feature helped me find my way.”

As might be expected for features designed to assist in congestion avoidance, not way-finding, respondents indicated that they saw little or no connection between these features and way-finding. The mean ratings were 3.8, 3.4, and 3.4 respectively. Only the rating for the Guidance Displays technique of displaying updated traffic information was significantly greater than the neutral rating of 3.5 ($p < .05$).

Local Users. Despite the fact that the local users were presumed to be much more familiar with the Orlando area than renters, their perceptions of the way-finding benefits of TravTek were very similar to that of the renters.

With two exceptions, local users were asked the same way-finding questions as renters. Table 12 summarizes local user responses to those questions. Local users were not asked to rate whether the Swap Map or Navigation Display helped them find their way. The local user summary is averaged over questionnaires for N and N+ modes, as no trends towards differences in responses across N+ and N questionnaires were detected.

Summary. the TravTek system and its primary route guidance visual and aural displays were perceived by rental and local users as helpful for way-finding.

Travel Time. Both renters and local users tended to perceive that TravTek helped them save time.

Two other evaluation studies, the Orlando Test Network Study and the Yoked Driver Study demonstrated empirically that the TravTek system yields time savings in both trip planning and travel time.^(10,7) Rental and local user perceptions of time saving are important because no matter how large the actual time saving may be, if users do not perceive a time saving they will be less likely to purchase and use TravTek-like devices. If the system is not used, then network-wide benefits, as projected by the TravTek Evaluation Modeling Study, would not be realized.⁽⁸⁾

Renters. One item in the questionnaire specifically addressed travel time saving: ‘Do you think TravTek helped you save time in reaching your destinations?’ The anchors for this question were one, “Didn’t save any time” and, six, “Saved a considerable amount of time.” As shown in table 13, N+ and N configuration rental users were about equally strong in agreeing with the assertion that TravTek helped save time. S users’ ratings of time savings were low, as might be expected for a system that provided neither route planning or route guidance.

Locals. Local users drove in both the N+ and N configurations and provided similar ratings for the helped me save time assertion; their mean rating was 4.5 for both questionnaires. Local user

ratings were similar regardless of which configuration they drove during their first and second month with the vehicle.

Table 12. Local user's perceptions of TravTek's ability to help them find their way.

Question	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>	<i>No Response</i>	<i>Did Not Use</i>
Overall, the TravTek system	5.4	5.23	5.66	51	0	na*
The TravTek system's Guidance Display	5.5	5.24	5.72	51	0	0
The TravTek system's Route Map	5.3	5.05	5.53	51	0	0
The TravTek system's Voice Guide Feature ("Turn right on Robinson" button located on steering wheel)	5.1	4.71	5.39	50	1	0
The TravTek system's Zoom In/Zoom Out Feature	5.0	4.62	5.40	33	14	4
Overall, the steering wheel buttons	4.9	4.58	5.23	51	0	na*
The TravTek system's OK NEW ROUTE feature(located on the steering wheel)	5.1	4.80	5.37	50	1	0
The TravTek system's WHERE AM I feature ("Heading west on Colonial"; Button located on steering wheel)	4.7	4.38	5.10	51	0	0
The TravTek system's REPEAT VOICE feature ("The last message was..."; button located on steering wheel")	4.4	4.00	4.87	47	0	4
The TravTek system's Hop Right/Hop Left feature (located on the steering wheel)	4.0	3.45	4.59	34	17	0

Table 13. TravTek rental users ratings of the assertion that TravTek helped save time in reaching destinations.

	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>	<i>Missing</i>
N+	4.7	4.57	4.75	804	25
N	4.6	4.50	4.72	622	20
S	2.6	2.33	2.93	135	19

Trip Generation. Questionnaire responses suggest that TravTek rental users, most of whom were visitors to the Orlando area, perceived that they took more and longer trips as a result of having in vehicle route planning and route guidance. The questionnaire data also suggest that renters used real-time traffic information to help in planning trips.

Renters were asked, "Did having the TravTek System in your car have any effect on the length or number of trips you took?" Only N+ and N configuration drivers were asked this question. Among renters, 537, or 34 percent, answered "yes," indicating that the number or length of their trips was influenced by TravTek. There was no tendency for N+ and N configuration renters to differ in answering this question. Only six local users were asked trip generation questions. This sample was too small to warrant analysis, but nothing in the obtained local user responses suggests a response pattern different from that of renters.

To indicate the nature of the change, respondents who said that trip frequency or length had changed were asked to indicate, on a scale from one to six, where one represented “never” and six represented “frequently” the frequency of having taken more, fewer, shorter, and longer trips. Table 14 shows how renters who answered “yes” described the nature of the perceived influence on the number of trips. Table 15 shows how renters who answered “yes” described the perceived influence on the length of trips. It can be seen that N+ and N configuration drivers showed the same pattern of response. Forty-five percent of the respondents indicated that at least occasionally (response greater than one) TravTek caused them to take fewer trips, whereas more than 98 percent indicated that TravTek, at least occasionally, led them to take more trips. Local users were not asked trip generation questions.

Table 14. Perception of increase or decrease in the number of trips taken by renters who said that the number or length of trips they took was influenced by TravTek.

Anchor		Fewer trips				More Trips			
		N+		N		N+		N	
		N	Percent	N	Percent	N	Percent	N	Percent
Never	1	155	57.2 %	104	59.4 %	10	3.2 %	3	1.5 %
	2	79	29.2 %	40	22.9 %	5	1.6%	4	2.0 %
	3	25	9.2 %	21	12.0%	16	5.2%	6	2.9 %
	4	8	3.0%	6	3.4 %	85	27.4 %	83	40.5 %
	5	1	.4%	3	1.7%	136	43.9%	67	32.7 %
Frequently	6	3	1.1%	1	.6%	58	18.7 %	42	20.5 %
Total		271	100.0 %	175	100.0 %	310	100.0 %	205	100.0 %

Table 15. Perception of change in length of trips by renters who said that the number or length of trips they took was influenced by TravTek.

Anchor		Shorter Trips				Longer Trips			
		N+		N		N+		N	
		N	Percent	N	Percent	N	Percent	N	Percent
Never	1	56	20.7 %	46	26.0 %	28	10.0 %	16	8.7 %
	2	60	22.2 %	33	18.6 %	21	7.5 %	14	7.7 %
	3	63	23.3 %	33	18.6 %	52	18.5 %	28	15.3 %
	4	44	16.3 %	21	11.9 %	65	23.1 %	53	29.0 %
	5	31	11.5 %	32	18.1 %	84	29.9 %	45	24.6 %
Frequently	6	16	5.9 %	12	6.8%	31	11.0 %	27	14.8 %
Total		270	100.0 %	177	100.0 %	281	100.0 %	183	100.0 %

Renters were also asked, “Did you ever change your plans to visit a destination based on the information you received from TravTek?” There were 62 N+ drivers (7.5 percent) and 56 N drivers (8.7 percent) who answered “yes” to this question. The drivers who answered “yes” were asked to estimate how frequently they changed destinations, delayed trips, or canceled trips because of TravTek. Their responses are shown in table 16. Note that not all respondents who answered “yes” to the former question provided estimates in the latter items.

Table 16. Renter perceptions of the frequency altered trip plans.

		<i>Changed Destination</i>				<i>Delayed Trip</i>				<i>Canceled Trip</i>			
		<i>N+</i>		<i>N</i>		<i>N+</i>		<i>N</i>		<i>N+</i>		<i>N</i>	
		<i>N</i>	<i>Percent</i>	<i>N</i>	<i>Percent</i>	<i>N</i>	<i>Percent</i>	<i>N</i>	<i>Percent</i>	<i>N</i>	<i>Percent</i>	<i>N</i>	<i>Percent</i>
Never	1	1	1.8 %	13	25.5 %	24	43.6 %	27	58.7 %	31	56.4 %	26	57.8 %
	2	11	19.3 %	13	25.5 %	19	34.6 %	8	17.4 %	16	29.1 %	9	20.0 %
	3	14	24.6 %	16	31.4 %	8	14.6 %	8	17.4 %	2	3.6 %	7	15.6 %
	4	23	40.4 %	6	11.8 %	1	1.8 %	3	6.5 %	4	7.3 %	3	6.7 %
	5	7	12.3 %	3	5.9 %	1	1.8 %			2	3.6 %		
Frequently	6	1	1.8 %			2	3.6 %						
Total		57	100.0 %	51	100.0 %	55	100.0 %	46	100.0 %	55	100.0 %	45	100.0 %

Of N+ and N configuration renters who said they altered plans to visit a destination because of TravTek, those with N+ were more likely than those with N to say that they changed destinations ($\chi^2(3) = 22.4, p < 0.0001$). Although respondents were not asked why they changed destinations, this finding is consistent with the use of real-time information to avoid trips into heavy congestion or to facilities with closed parking lots. The apparent trend for N+ drivers to delay trips more often than N drivers is not statistically reliable ($p > 0.10$).

Safety. Users perceived that TravTek helped them drive more safely. Furthermore, renters who had TravTek navigation and route guidance displays available while driving, perceived that they had about the same rate of close calls (or near accidents) as drivers in the control (S) configuration, who had no TravTek functions available while driving.

The TravTek questionnaire approached possible effects of the system on driving safety from several perspectives. In addition to asking users whether the system helped them drive more safely, users were asked about their experience of “close calls” and the cause of close calls (if any). Closely related to safety are the issues of whether TravTek was perceived to help users pay attention to their driving or perceived it to interfere with their driving. The latter, related issues, are dealt with in the section that follows.

Did you drive more safely? Respondents were asked “Do you think TravTek helped you drive more safely in Orlando?” The anchors for this question were, one, “Didn’t help me drive safely,” and six, “Helped me drive more safely.” The mean ratings for renters are shown in table 17. N+ and N configuration rental drivers tended to indicate that TravTek helped them drive more safely, whereas the S configuration drivers, who did not have any TravTek functions available while they were driving, tended to indicate that TravTek did not help them drive more safely.

Table 17. TravTek rental user responses to the assertion that TravTek helped them drive more safely.

	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N</i>
N+	4.1	4.03	4.23	904
N	4.0	3.88	4.14	625
S	2.4	2.15	2.20	131

There were 48 local users who answered the “Helped me drive more safely” question for both months one and two. Their mean rating, 4.0, was the same as that for the renters, and did not differ as a function of vehicle configuration, or the order in which the configurations were tested.

Close Calls. Another safety related question asked “How many times did you experience ‘close calls’ (or near accidents) while driving the vehicle?” There were two versions of this question that varied only in the labels on the anchors. Early questionnaires used the anchors “None” and “Many” for one and six respectively, whereas in later questionnaires the anchors were changed to “Never” and “Frequently.” There were no differences in the pattern of responding with the change in anchors. The frequency distribution for responses from 1,670 rental respondents to this question are shown in table 18. Close call frequency ratings did not vary as a function of vehicle configuration ($\chi^2 (10) = 12.88, p > 0.22$). Overall, 18.4 percent of renters perceived that they had had one or more close calls.

Table 18. Distribution of renter responses to the question “How frequently did you experience ‘close’ (or near accidents) while driving the vehicle?”

<i>Response</i>	N+		N		S	
	<i>Frequency</i>	<i>Percent</i>	<i>Frequency</i>	<i>Percent</i>	<i>Frequency</i>	<i>Percent</i>
"None/Never" 1	665	82	495	80	119	87
2	105	13	95	15	10	7
3	20	2	18	3	6	4
4	15	2	10	2	1	1
5	3	0	1	0	0	0
"Many/Frequently" 6	1	0	3	0	1	1
Total	809	100	622	100	137	100

The reported perception of close call frequency for local users is shown in table 19.

Table 19. Distribution of local user responses to the question “How frequently did you experience ‘close’ (or near accidents) while driving the vehicle?”

<i>Response</i>	N+		N	
	<i>Frequency</i>	<i>Percent</i>	<i>Frequency</i>	<i>Percent</i>
"None/Never" 1	25	54	28	61
2	17	37	15	33
3	2	4	2	4
4	2	4	1	2
5	0	0	0	0
"Many/Frequently" 6	0	0	0	0
Total	46	100	46	100

There were no apparent differences in the perceived frequency of close calls among drivers who had N+ and N configurations, nor between those drivers and drivers with the S configuration.

Among those drivers who perceived that they had had close calls, that is, drivers circling 2 or higher, there was no difference in the tendency to attribute traffic congestion as a cause of the close call. In response to the question “To what degree was congestion a factor?” where the an-

chors were “None of the time” and “Ah of the time” for one and six respectively, the mean rating was 2.8 for all three renter configurations. The local user means for were 3.0, and 3.6 for the N and N+modes, respectively.

To further our understanding of what drivers perceived to be the cause of the close calls they perceived, drivers who perceived close calls were asked what actions inmediately preceded the close call(s). Table 20 shows the activities from which they could select. Respondents could choose as many of the activities as applied and therefore the sum of frequencies in the table is greater than the number of drivers indicated in the last row. Because drivers with the S configuration did not have access to TravTek functions when in DRIVE, the three TravTek functions listed are not applicable (na) for S.

Table 20. Activities renters said they were doing immediately prior to close calls.

<i>Activities</i>	<i>N+</i>	<i>N</i>	<i>S</i>
Operating non-TravTek features	18	24	8
Operating TravTek Features	39	21	na
Looking at TravTek display	63	58	na
Listening to TravTek voice message	16	7	na
Using cellular phone	5	6	5
Normal driving actions	68	60	8
Number Reporting Close Calls	144	127	18

Forty-five percent of the renters who perceived close calls said they were looking at TravTek displays just before the close call. Although this is interesting, the frequency of perceived incidents was low (only 18.4 percent of renters), and of equal likelihood across N+, N and S (control) configurations. Furthermore, renters claimed a safety benefit overall (TravTek helped me drive more safely), and, as shall be shown in the next section, disagreed with the assertion that TravTek interfered with their driving. Table 21 shows the activities that local users indicated they were doing just before close calls. The local user pattern appears similar to that for the renters.

Table 21. Activities local users said they were doing immediately prior to close calls,

<i>Activities</i>	<i>N+</i>	<i>N</i>
Operating non-TravTek features	5	5
Operating TravTek Features	4	6
Looking at TravTek display	10	8
Listening to TravTek voice message	0	1
Using cellular phone	5	5
Normal driving actions	14	10
Number Reporting Close Calls	21	18

Although there was no indication that close calls were more likely to occur among TravTek users, a further exploration of perceptions of safety was performed for renters who said they were looking at, operating, or listening to TravTek just before a close call. These drivers were neutral with respect to the “helped me drive more safely” question. Their mean response to that question was 3.3, with a 95 percent confidence interval of 3.01 to 3.55. Their rating was significantly lower than the rating for the N+ and N samples as a whole.

Drivers who perceived close calls were also asked “Who or what caused the close call?” Those who said they were looking at, operating, or listening to TravTek just before a close call were far more likely to see themselves as a contributing cause ($p < 0.001$). Table 22 shows the frequency, for renters, of attributions to each of the categories provided in the questionnaire. The percentages shown in the table are of the number of respondents and do not add to 100 because respondents could check all categories that applied. That is, a respondent might indicate that both “myself” and the “driver of another vehicle” caused the close call. Responses from drivers in the S configuration are shown with drivers who were not interacting with TravTek, because S drivers could not interact with TravTek while driving. The local user findings for attribution of cause of close calls followed the same pattern as that for the renters and, to conserve space, is not shown here.

Table 22. Stated cause of close calls by renters.

Renters reporting close calls that occurred immediately after an interaction with TravTek						
Cause	N+		N			
	Frequency	Percent	Frequency	Percent		
Myself	51	66%	53	78%		
Driver of another vehicle	25	32%	24	35%		
Road debris	0	0%	4	6%		
Roadside signs	9	12%	4	6%		
Other	13	17%	7	10%		
Number of Resnondents	77		68			
Renters reporting close calls that did not follow interaction with TravTek						
Cause	N+		N		S	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Myself	15	22%	21	36%	9	50%
Driver of another vehicle	40	60%	29	49%	7	39%
Road debris	2	3%	3	5%	0	0%
Roadside signs	2	3%	5	8%	4	22%
Other	5	7%	4	7%	2	11%
Number of Respondents	67		59		18	
Total Respondents Reporting Close Call(s)	144		127		18	

Although drivers who said they were interacting with TravTek before a close call tended to hold themselves responsible for the close call, they were not different in attribution of cause from drivers who said they were interacting with other devices in the vehicle. Table 23 shows the attribution of cause by drivers who said they were operating non-TravTek features or the cellular phone just prior to a close call. Because the cellular phone could not be accessed through the TravTek system while the vehicle was in gear, the cellular phone is not a TravTek feature in this instance (if it is assumed that close calls occurred only when the vehicle was in gear). The percentage of drivers that reported close calls associated with the use of in-vehicle devices not related to TravTek and attributing close calls to themselves is not significantly different from the percentage who attributed close calls to themselves and said they were interacting with TravTek before a close call.

Table 23. Attribution of close call cause by renters who said they were operating non-TravTek in-vehicle features just before a close call.

<i>N+ and N</i>		
	<i>Frequency</i>	<i>Percent</i>
Myself	35	69%
Driver of another vehicle	23	45%
Road debris	3	6%
Roadside signs	8	16%
Other	2	4%
Number of Respondents	51	

Summary. Participants of both studies tended to agree that TravTek helped them drive more safely. The number of renters who reported experiencing close calls was proportionally equivalent among TravTek and S (control) drivers. Slightly less than half the TravTek users who reported close calls said they had been looking at a TravTek display, or otherwise interacting with TravTek just prior to a close call incident. Those drivers who reported interacting with TravTek just prior to a close call tended to blame themselves for the incident. However, this should not be assumed to implicate TravTek as a cause of close calls. Respondents operating non-TravTek in-vehicle devices also tended to blame themselves for close calls. Furthermore, the S group — that did not have TravTek displays while driving — was equally likely to report close calls. The *TravTek Evaluation Task C3 - Camera Car Study* final report contains a detailed analysis of close calls that were recorded on video.(6)

These data may imply that drivers will be less than fully attentive to the roadway a certain proportion of the time, and if a device such as TravTek is in the vehicle, their attention may be diverted to it. However, there is no evidence that the availability of the device is the cause of the inattention to driving. To the contrary, TravTek users indicated that TravTek helped them pay more attention to their driving.

Several other TravTek reports address the safety issue. In particular, the TravTek Safety Study Final Report integrates the TravTek safety findings across studies and reports the effects of modeling extrapolations from TravTek findings to network wide effects.⁽¹¹⁾

Interference with, and Attention to, Driving. Mental workload is a concept that has many theoretical definitions, but in general is based on the concept that people have a finite amount of mental resources that they can devote to, or divide among, tasks. The questionnaires contained several items that address how drivers perceived TravTek's effects on mental resources. These findings are presented following the safety findings because it is generally accepted that regulating the demands on drivers' mental resources is important to safety.

Interference with Driving. TravTek users did not perceive the system to interfere with their driving.

In assessing many of the TravTek system's functions and features, drivers were asked to rate their agreement with the assertion that each function or feature "Interfered with my driving." For all of these ratings the anchor for one was "Strongly disagree," and the anchor for six was "Strongly

agree.” Table 24 lists the questions and findings for the “Interfered with my driving” items. One item in the table “The screen was distracting at night” was not introduced with the phrase “Interfered with my driving” but is conceptually related to the concept of interference, and therefore is included here. For all of these question, there were no statistically reliable differences between N+ and N responses. S configuration drivers were not included in the table because they did not have TravTek functions available while they were driving. Therefore, table 24 includes data from 1,577 N+ and N configuration drivers.

Table 24. Rental users’ assessment of whether TravTek interfered with their driving.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>	<i>No Response</i>	<i>Did Not Use</i>
Overall, the TravTek system	2.1	2.01	2.13	1524	53	Na*
The TravTek system’s Guidance Display	2.4	2.31	2.46	1378	165	34
The TravTek system’s Route Map	2.3	2.22	2.35	1440	98	39
The TravTek system’s Voice Guide Feature (“Turn right on Robinson” button located on steering wheel)	1.8	1.75	1.88	1365	83	129
The TravTek system’s technique of displaying a local map for driving without a destination	2.1	2.01	2.15	1157	81	339
The TravTek system’s Zoom In/Zoom Out Feature	2.3	2.22	2.36	1349	6	152
Overall, the steering wheel buttons	2.0	1.98	2.11	1497	80	Na*
The TravTek system’s SWAP MAP feature	2.2	2.14	2.31	1036	85	456
The TravTek system’s OK new route feature (located on the steering wheel)	2.3	2.224	2.39	1285	101	191
The TravTek system’s WHERE AM I feature (“Heading west on Colonial”; Button located on steering wheel)	1.8	1.75	1.87	1227	81	269
The TravTek system’s Hop Right/Hop Left feature (located on the steering wheel)	2.5	2.44	2.64	802	117	658
The screen was distracting at night	1.8	1.76	1.88	1493	84	Na*

Table 25 summarizes local users responses to the interfered with my driving questions.

As can be seen in table 24, the TravTek features that were seen as least interfering by renters were related to the synthesized voice. The Voice Guide, REPEAT VOICE, and WHERE AM I. Local users tended to rate TravTek as less interfering than renters, perhaps because of their greater experience with the system.

Table 25. Local users' assessment of whether TravTek interfered with their driving,

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
Overall, the TravTek system	1.9	1.58	2.13	51
The TravTek system's Guidance Display	2.0	1.75	2.30	50
The TravTek system's Route Map	2.0	1.70	2.24	51
The TravTek system's Voice Guide Feature ("Turn right on Robinson" button located on steering wheel)	2.0	1.68	2.37	51
The TravTek system's Zoom In/Zoom Out Feature	1.8	1.45	2.16	33
Overall, the steering wheel buttons	1.9	1.58	2.18	51
The TravTek system's SWAP MAP feature	1.9	1.62	2.25	49
The TravTek system's OK new route feature (located on the steering wheel)	2.1	1.83	2.42	51
The TravTek system's WHERE AM I feature ("Heading west on Colonial"; Button located on steering wheel)	1.6	1.36	1.89	51
The TravTek system's REPEAT VOICE feature ("The last message was..."; button located on steering wheel")	1.8	1.46	2.09	47
The TravTek system's Hop Right/Hop Left feature (located on the steering wheel)	2.1	1.67	2.53	34
The screen was distracting at night	1.7	1.37	2.15	36

Given that a neutral response (neither agree nor disagree) would have been 3.5, respondents disagreed with the assertion that TravTek, its features or functions, interfered with their driving. Table 26 shows the responses to the "Interfered with my driving" items from the 145 drivers who reported interacting with TravTek just before a close call. Whereas these drivers were less adamant that TravTek did not interfere with their driving, their responses are consistent with those from the larger population; the TravTek system was not perceived to interfere with driving.

Attention to Driving. Respondents were also asked the converse of "Interfered with my driving," that is, "Helped me pay more attention to my driving." Both renters and local users agreed that TravTek helped them pay attention to their driving.

As can be seen in table 26, renters generally agreed with the assertion that TravTek helped them pay more attention to their driving.

The Voice Guide feature was far and away the feature seen by renters as most helpful with attention to driving.

The hop right and hop left feature, that enabled drivers to laterally correct the position of the vehicle icon on the Route Map or Navigation Display (the map without a planned route), was not viewed as helpful to attention to driving. The hop left and hop right steering wheel buttons could place the vehicle's dead reckoning and map matching algorithm back onto the correct roadway if the system had located the vehicle icon on a parallel roadway. This feature was provided to correct occasional navigation errors made by the TravTek system. A neutral rating here may be interpreted as favorable, given that system errors might be expected to be somewhat distracting.

Table 26. “Interfered with my driving” data for drivers who reported that they were interacting with TravTek just before a close call.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>	<i>No Response</i>	<i>Did Not Use</i>
Overall, the TravTek system	2.9	2.66	3.11	142	3	Na*
The TravTek system’s Guidance Display	3.4	3.10	3.63	126	13	6
The TravTek system’s Route Map	3.0	2.81	3.27	139	4	2
The TravTek system’s Voice Guide Feature (“Turn right on Robinson” button located on steering wheel)	2.1	1.86	2.28	130	4	11
The TravTek system’s technique of displaying a local map for driving without a destination	2.9	2.68	3.18	114	4	27
The TravTek system’s Zoom In/Zoom Out feature	3.0	2.75	3.24	131	4	10
Overall, the steering wheel buttons	2.6	2.34	2.78	142	3	Na*
The TravTek system’s SWAP MAP feature	2.9	2.61	3.18	105	5	35
The TravTek system’s OK new route feature (located on the steering wheel)	2.9	2.65	3.15	122	6	17
The TravTek system’s WHERE AM I feature (“Heading west on Colonial”; Button located on steering wheel)	2.1	1.87	2.29	126	5	14
The TravTek system’s REPEAT VOICE feature (“The last message was...”; button located on steering wheel”)	2.2	2.01	2.45	119	3	23
The TravTek system’s Hop Right/Hop Left feature (located on the steering wheel”)	3.1	2.69	3.41	79	10	56
The screen was distracting at night	2.1	1.95	2.33	139	6	Na*

Local user ratings for the attention to driving items, shown in table 28, were similar to those from the renters. Local users agreed that the Voice Guide helped them pay attention to about the same degree as renters.

Other Safety Related Impressions. Rental and local users were also asked to compare how they felt while driving with TravTek compared to how they feel driving a rental car (without TravTek). Specifically, they were asked to rate on a one to six scale whether they felt less (one) or more (six): nervous, confused, confident, attentive, and safe. Both renter and local user groups indicated that they felt less nervous and confused with TravTek, and more confident, attentive, and safe, as shown in table 28. There were no difference between ratings for N+ and N configurations, which suggests that the benefit derived from functions related to route guidance rather than from real-time traffic information. Local users were significantly more positive than renters regarding greater feelings of safety and attentiveness and reduced feelings of confusion and nervousness.

Summary. Renters and local users perceived TravTek as an aid that enabled them to pay more attention to their driving. They did not perceive TravTek to interfere with their driving. They perceived TravTek to interfere with their driving. They perceived TravTek to make them feel more attentive, confident, and safe, and less nervous and confused.

Table 27. Renters' agreement with the assertion that TravTek features and functions
"Helped me pay more attention to my driving."

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>	<i>No Response</i>	<i>Did Not Use</i>
Overall, the TravTek system	4.5	4.40	4.54	1527	50	Na*
The TravTek system's Guidance Display	4.2	4.13	4.28	1485	58	34
The TravTek system's Route Map	4.3	4.19	4.33	1447	91	39
The TravTek system's Voice Guide Feature ("Turn right on Robinson" button located on steering wheel)	5.0	5.00	5.11	1367	81	129
The TravTek system's technique of displaying a local map for driving without a destination	4.4	4.33	4.49	1161	77	339
The TravTek system's Zoom In/Zoom Out Feature	4.1	4.03	4.18	1346	79	152
Overall, the steering wheel buttons	4.4	4.31	4.45	1492	85	Na*
The TravTek system's SWAP MAP feature	4.3	4.20	4.37	1042	79	456
The TravTek system's OK NEW ROUTE feature (located on the steering wheel)	4.3	4.24	4.40	1288	98	191
The TravTek system's WHERE AM I feature ("Heading west on Colonial"; Button located on steering wheel")	4.5	4.40	4.57	1224	84	269
The TravTek system's REPEAT VOICE feature ("The last message was..."; button located on steering wheel")	4.4	4.31	4.49	1091	84	402
The TravTek system's Hop Right/Hop Left feature (located on the steering wheel)	3.5	3.42	3.63	803	116	658

Table 28. Local users' agreement with the assertion that TravTek features and functions
"Helped me pay more attention to my driving."

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
Overall, the TravTek system	4.9	4.55	4.15	50
The TravTek system's Voice Guide Feature ("Turn right on Robinson" button located on steering wheel)	4.8	4.42	5.13	51
The TravTek system's Guidance Display	4.8	4.49	5.05	50
The TravTek system's WHERE AM I feature ("Heading west on Colonial"; Button located on steering wheel)	4.7	4.38	5.00	50
Overall, the steering wheel buttons	4.6	4.23	4.93	51
The TravTek system's Route Map	4.6	4.29	4.96	51
The TravTek system's OK NEW ROUTE feature (located on the steering wheel)	4.5	4.18	4.85	51
The TravTek system's technique of displaying a local map for driving without a destination	4.2	3.13	5.20	6
The TravTek system's REPEAT VOICE feature ("The last message was..."; button located on steering wheel")	4.2	3.78	4.67	47
The TravTek system's Zoom In/Zoom Out Feature	4.2	3.77	4.71	33
The TravTek system's Hop Right/Hop Left feature (located on the steering wheel)	4.0	3.49	4.45	34

Table 29. User ratings of safety related feelings when driving with TravTek.

	Feeling	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N</i>
Renters	Nervous	2.3	2.25	2.36	1518
	Confused	2.2	2.18	2.29	1522
	Confident	4.8	4.76	4.86	1539
	Attentive	4.4	4.31	4.43	1506
	Safe	4.5	4.46	4.57	1507
Local Users	Nervous	1.9	1.68	2.15	49
	Confused	1.9	1.68	2.09	49
	Confident	5.1	4.71	5.38	50
	Attentive	4.8	4.48	5.08	50
	Safe	5.0	4.70	5.23	50

Which In-Vehicle Features Do Drivers Prefer and What is the Frequency of Use of Each Feature?

In the last section we examined how drivers perceived the TravTek system to affect their navigation and driving performance. In this section we examine which aspects of the TravTek system drivers preferred from two perspectives: what they said they preferred, and how much they used particular features. In the questionnaires, local users and renters were asked which voice and visual display combinations they liked and preferred. In-vehicle data logs provide records of which visual displays users selected and whether the Voice Guide was turned on or off. Together, these data sources provided a rounded picture of the TravTek experience.

Display Formats. In questionnaires, users were asked to rate how well they liked the two route guidance visual displays, with and without the Voice Guide. All ratings were on a scale from one to six, where one was labeled “disliked” and six was labeled “liked.”

Rental user ratings for the visual displays with and without supplemental voice guidance are shown in table 30. It can be seen that the renters strongly preferred the visual displays supplemented by voice guide and were nearly neutral with respect to the visual displays without voice supplement. Ratings of renters that had traffic information (N+) did not differ from those who did not (N).

Local users, whose mean ratings are also shown in table 30, were positive towards all the display combinations, but were most positive towards the route map without voice supplement. The interaction of visual display and Voice Guide was statistically reliable ($F(1, 40) = 6.85, p < 0.05$). No effects of traffic information or experience (first month/second month) were detected among the 42 local users that provided complete responses.

Table 30. Rental and Local user ratings of liking for the visual route guidance displays with and without supplemental voice guidance.

<i>Study</i>	<i>Visual Display</i>	<i>Voice Guide</i>	
		<i>On</i>	<i>Off</i>
<i>Renters</i>	Guidance Display	5.3	3.6
	Route Map	5.2	3.7
<i>Local Users</i>	Guidance Display	4.6	4.6
	Route Map	4.5	5.0

Some local users were asked “Of the two routing displays, Route Map and Guidance Display, which did you prefer?” Two opportunities to respond were provided with ratings on a scale where one represented “Strongly prefer Route Map” and six represented “Strongly prefer Guidance Display.” The two ratings were with respect to “All driving situations” and “In most driving situations.” It can be seen in table 31 that there were two non-significant trends: a slight preference for the Guidance Display and a tendency for that preference to lessen with experience,

Both renters and local users were asked whether they liked using the Voice Guide alone (without the visual display). The local user preference findings for Voice Guide alone (N = 39) are shown in table 32. Local users who received traffic information during their first month of participation rated the Voice Guide alone positively, whereas Voice Guide alone received neutral to negative ratings when traffic information was not available, or when traffic information was provided during the second month of participation. These findings are curious because the Voice Guide worked the same regardless of the availability of traffic information.

Table 31. Local user preference for Route Map (one) or Guidance Display (six).

	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N</i>
End of First Week¹				
In all driving situations	4.0	2.80	5.20	11
In most driving situations	4.3	3.16	5.34	12
End of First Month				
In all driving situations	3.4	2.58	4.26	19
In most driving situations	4.2	3.31	4.99	20
End of Second Month				
In all driving situations	3.3	2.63	4.07	23
In most driving situations	3.8	3.04	4.5	25

¹ Twelve local users who also participated in the Camera Car Study received a questionnaire at the end of the first week of participation. These questionnaire findings are reported here because they appear to clarify a trend display preference.

Table 32. Mean local user ratings of like (six) or dislike (one) for the Voice Guide without visual display.

	<i>Month One</i>	<i>Month Two</i>
<i>N+</i>	4.11	2.9
N	3.05	3.26

Renters rated Voice Guide alone 2.9. In general, renters did not like the Voice Guide without visual display. It should be pointed out that the Voice Guide was designed as a supplement to the visual displays and the results might have been different with a Voice Guide specifically designed to stand alone. It should also be noted that there is no way to verify that users actually used Voice Guide alone, as in-vehicle log data only indicate whether the Voice Guide was on, or off, and which TravTek visual display was selected. Users could use Voice Guide alone by ignoring the visual display, or switching the visual display to a non-TravTek function such as climate control. The in-vehicle log did not record the selection of non-TravTek visual displays.

Summary. Renters, who were primarily out-of-town visitors, preferred visual navigation displays accompanied by supplemental voice guidance. Local users, who were familiar with the local area, showed a slight preference for the route map without voice guidance. Ratings for the Voice Guide alone were close to neutral (neither liked nor disliked).

Route Planning. Whereas what drivers said is interesting, the interpretation of what they said may be colored by what they actually did. The in-vehicle data log recorded usage of TravTek functions and features. This section examines usage of the TravTek system for planning trips and following routes.

Renters. The in-vehicle data for rental user analysis are from 1,327 vehicle rentals for which a total of 33,178 trips¹ were recorded by 1,597 drivers. Renters used TravTek to plan routes for 55 percent of their trips. As shown in figure 7, renters with real-time traffic information (N+) were more likely than others (N) to plan trips using TravTek ($F(1, 1113) = 12.33, p < 0.001$). N+ renters installed planned routes on 57 percent of their trips whereas N renters installed planned routes on 51 percent of their trips. Route planning usage declined as the number of trips increased ($F(2, 1113) = 36.57, p < 0.01$). There are several plausible explanations for the decline in use over time: usage might be expected to decline as the user became more familiar with the area; early high usage might be due to the novelty of the TravTek system; or drivers who took more trips may have taken a number of shorter trips that did not require guidance. Regardless of the cause of the trend towards reduced usage, usage remained above 42 percent of all trips among renters who took 40 or more trips.

Local Users. The amount of route planning usage by these high mileage local users was remarkably similar to the proportion of trips that rental users installed planned routes. The in-vehicle data for local user analyses come from 44 local users for whom data are available for 10,595 trips. Local users installed planned routes for 4,483 of those trips. In-vehicle data were available for the full 2 months of use for 32 local users. Local users were about equally likely to install planned routes for their trips when using the N+ and N configurations. It can be seen in figure 8 that there was a decline in usage of the route planning function from the first month to the second month. The decline is statistically reliable ($F(1, 30) = 26.85, p < 0.001$).

¹ The definition of a trip used here required that the vehicle be started and moved. Other definitions of a “trip” are possible, and where other definitions are used they will be noted.

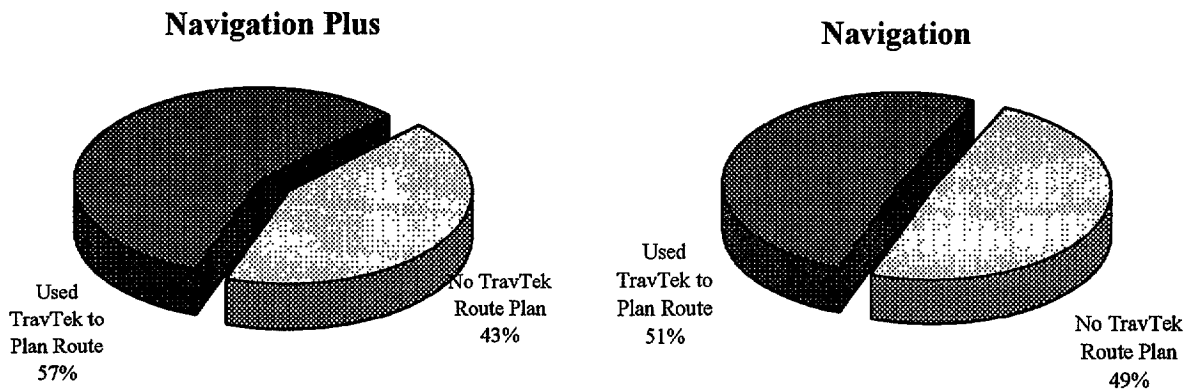


Figure 7. Percent of time that N+ and N configuration rental users planned and followed routes using the TravTek system.

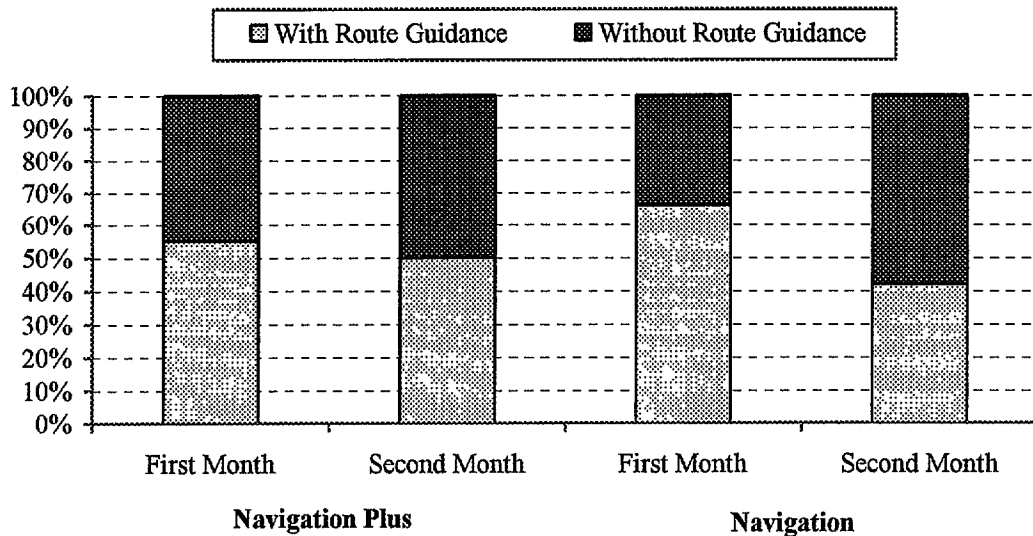


Figure 8. Percentage of trips that local users used the TravTek system's route planning function to guide them to destinations.

Display Use. Earlier it was shown that renters expressed a like for the Guidance Display and were neutral, neither expressing like nor dislike, for the Route Map. Local users expressed about equal liking for the Guidance Display and Route Map, and equal liking for each of those with, and without, the Voice Guide. Here we examine actual usage of the visual displays and Voice Guide.

Renters. Figure 9 shows the percentage of time per trip that renters used each display configuration with and without voice guidance.² This percentage was computed by first computing the average seconds per trip with each display configuration and then dividing by the mean trip length. Mean trip time was 956 s for N+ and 980 s for the N configuration. Consistent with their stated preference, renters used the Guidance Display more than the Route Map and drove with the Voice Guide on most of the time. When a route was planned, the system defaulted to the Guidance Display with the Voice Guide on. The user had to press the SWAP MAP button on the steering wheel hub to change to the Route Map, and press the VOICE GUIDE button on the steering wheel hub to turn the Voice Guide off.

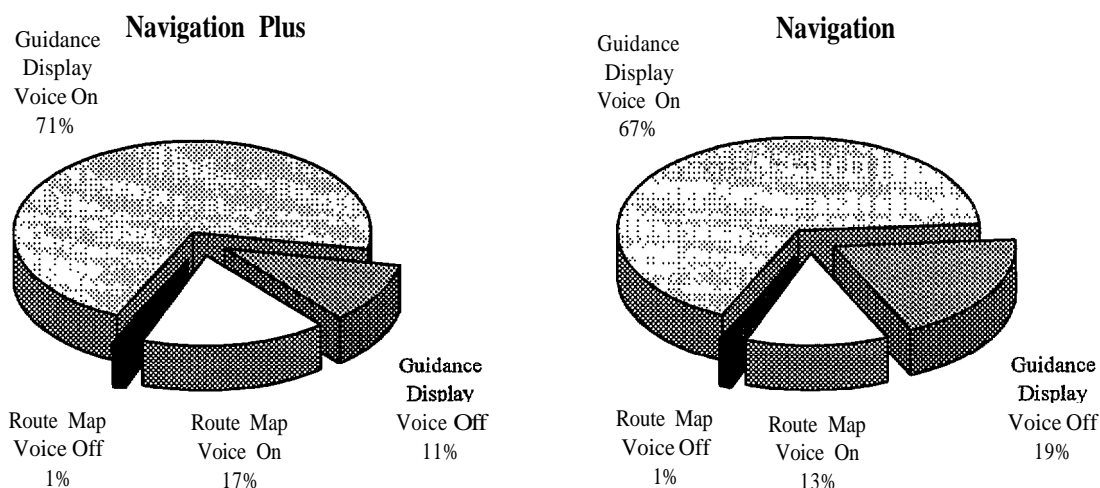


Figure 9. Rental user display use.

N+ renters made greater use of the Route Map and Voice Guide than did N renters. Because traffic information was shown on the Route Map, whereas only the availability of traffic information was shown on the Guidance Display, N+ users had a greater incentive to switch to the Route Map.

The method of switching from the default Guidance Display to the Route Map, and to switch back to the Guidance Display from the Route Map was to press the SWAP MAP button on the steering wheel hub. On average N+ drivers used the SWAP MAP more often than N drivers. N+ drivers pressed SWAP MAP an average of 3.1 times per trip whereas N drivers pressed SWAP MAP an average of 2.3 times per trip.³ Whereas a number of parametric and non-parametric analyses confirm the reliability of the trend for N+ renters to use SWAP MAP more often than N renters, the overall difference between modes is small, and is not necessarily representative of the

² Only trips for which routes were planned are included in this analysis. Furthermore, only those portions of trips for which the vehicle was on the planned route are included. The Route Map could only be displayed when a route was planned, and the Guidance Display could be viewed only when the vehicle was on a planned route.

³ See previous footnote.

typical user. 59.4 percent of N+ renters and 57 percent of N renters pressed SWAP MAP an average of once per trip. Furthermore, 28.9 percent of N+ and N rental questionnaire respondents reported that they did not use the SWAP MAP button.

Local Users. Local users also drove most often with the Guidance Display selected and with the Voice Guide on. Figure 10 shows mean percent of time per trip that local users had each of the display combinations selected. Local users used the Route Map more than the renters, and drove with the Voice Guide turned off more than renters.

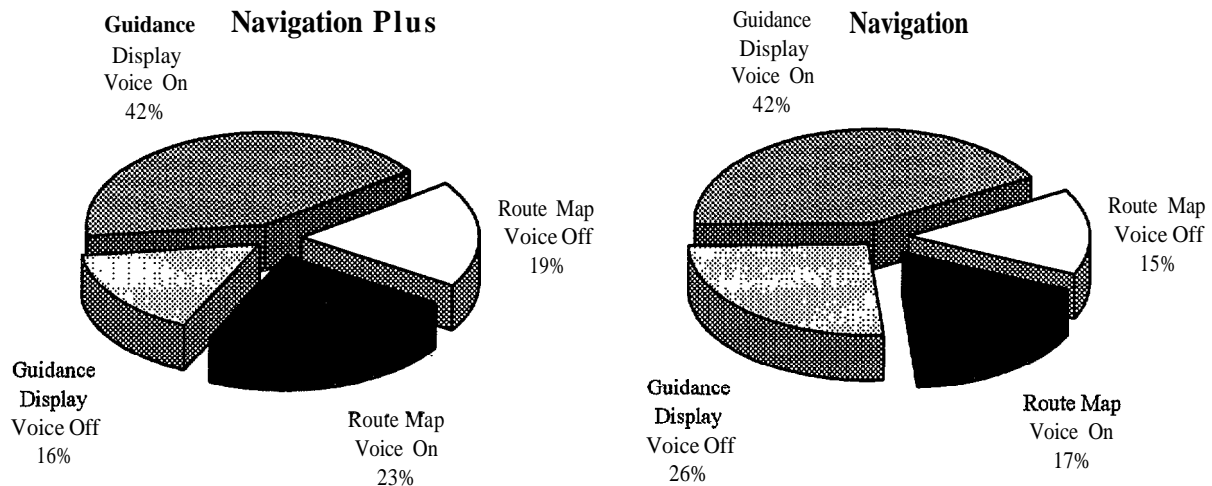


Figure 10. Local user display use.

Summary. The Guidance Display was used by most N+ and N renters over 80 percent of the time. Renters had the Voice Guide on over 90 percent of the time. Local users used the Guidance Display about 70 percent of the time, and had the Voice Guide about 70 percent of the time. N+ renters switched to the Route Map more often than N renters, and N+ renters kept the Route Map display on longer, perhaps for the traffic information. Among local users there was no difference in display use as a function of vehicle configuration (N+ versus N).

Acceptance of Better Routes Based on Real-Time Traffic Information. With the N+ configuration, while on a planned route, the TravTek system continually evaluated travel time projections and searched for faster routes. If a significant delay was detected on the planned route, and the system had detected a new route that would considerably reduce travel time, the driver was alerted with voice and screen messages to the availability of a faster route. The driver could accept the faster route by pressing the OK NEW ROUTE button on the steering wheel hub. This section examines drivers acceptance of better routes.

The occurrence of the faster route available message was rare. During the TravTek operational test there were 27 recorded instances on 21 renter trips (a faster route was offered more than

once on some trips).⁴ Among local users there were 15 recorded instances of faster routes offers, and no case in which a faster route was offered more than once on a single trip. Seven of the fifty-one local users were offered faster routes.

Renters. In all but four of the instances, the rental driver pressed OK NEW ROUTE when offered a faster route. The Voice Guide was on for all 27 instances, which implies, if one assumes the voice message was heard, that all the drivers were aware of the offer.⁵ At least one driver appears to have tried to accept the faster route but did not press the OK NEW ROUTE button. That driver repeatedly touched the TravTek display in the area of the “Faster route available--press OK NEW ROUTE” message banner.

Seven renters who accepted a faster route returned questionnaires. Those seven renters rated the TravTek system similarly to other N+ renters. Two of those seven indicated in the questionnaire that they had not been offered a faster route because of traffic conditions. Thus it appears that at least these two drivers did not fully understand the implications of the faster route available message. One of these two drivers indicated that the TravTek system never helped them avoid any congestion, whereas four of the remaining six gave ratings of 4 or more and the mean rating for all seven was 3.9 (3.5 would be neutral). For drivers who accepted better routes, it is conceivable that they still encountered congestion on the new route. The TravTek system was designed to select the fastest route; it would not avoid all congestion. Under extreme conditions, as when I-4 was closed, an event that happened twice during the operational test, alternative routes may have become extremely congested and still have been faster. Under these conditions, users given the fastest available route have perceived the system to be less useful than it was, because they were unaware of worse conditions on routes they did not take.

The seven rental questionnaire respondents who accepted faster routes rated TravTek significantly higher than other N+ drivers in response to the question “Do you think TravTek helped you save time in reaching your destinations?” For this question the anchors were, one, “Didn’t save any time,” and six, “Saved a considerable amount of time.” The seven drivers who accepted a better route gave a 5.1 mean response whereas N+ local users who were not offered faster routes gave a 4.7 mean response. Overall ratings of the TravTek system, and estimates of willingness to pay (discussed later), appeared unaffected by whether faster routes were offered or accepted.

Local Users. Among local users, better routes were accepted on 8 of the 15 recorded occasions that better routes were offered. These eight occasions were distributed among four local users. It appears that the critical variable in determining whether or not a faster route was accepted was

⁴ In vehicle log data were stored on a conventional 20 megabyte hard disk. There was some loss of data due to hard disk failures and errors that occurred when the data were downloaded from the vehicles. Better route available events were recorded in the in-vehicle logs, so it is possible that additional better route events occurred that were not recorded. Approximately 20 percent of the in-vehicle log data were not recovered.

⁵ The audio volume level of the Voice Guide was user adjustable. TravTek’s automatic data recording did not include volume level, only whether the system generated a message.

the Voice Guide. On six of the seven occasions that a local user did not accept a better route, the Voice Guide was turned off. On all eight occasions that a better route was accepted, the Voice Guide was on. There is a strong implication here that, if local users are aware that a faster route is available, they will accept the faster route.

As expressed in questionnaire responses, the four local users who accepted new routes did not appear to differ from the remaining local users in their perceptions of the utility, efficiency or value of the TravTek system.

Summary. It appears that when offered alternative routes because of traffic conditions, both renters and local users accept those routes. Drivers who did not accept new routes appear to either: (1) not understand the system sufficiently well, or (2) not be aware that the faster route was available. In the TravTek operational test, offers of new routes were rare, and drivers who accepted the new routes did not perceive the TravTek system to be more or less efficient than did drivers who were not offered better routes.

Traffic Report. The TRAFFIC REPORT button on the steering wheel hub turned TravTek's traffic report feature on and off. The traffic report feature presented synthesized voice messages of traffic conditions and incidents. When the vehicle was on a planned route, traffic reports were limited to the planned route. When the vehicle was not on a planned route, either because a route had not been installed, or because the vehicle was off route, traffic reports covered a wide area. By default, the traffic report feature was off. As traffic report relied on real-time traffic updates, it was only available with N+.

Renters. Among renters, 85 percent of 715 N+ for whom in-vehicle data logs were available turned the traffic report on at least once. Traffic report was on more often when a planned route was installed than when no route was planned ($t(527) = 6.58, p < 0.0001$). The traffic report feature was on an average of 14.3 percent of the time when a planned route was installed, and 11.2 percent of the time when TravTek was used without an installed route. Use of the traffic report declined as the number of trips taken increased, averaging about 12 percent of the time for renters' first eight trips and about 8 percent for beyond the 24th trip.

Local Users. Among local users, 94 percent of the 31 local users for whom in-vehicle logs were available used traffic report at least once. Locals used the traffic report function about the same amount whether or not a planned route was installed. Overall they used traffic report about 7 percent of the time. Nine local users used traffic report more than 10 percent of the time. Those nine users had traffic report on about 15 percent of the time. Locals usage of the traffic report did not appear to vary with experience. That is, usage was about the same for early trips as for later trips.

Traffic Report Ratings Among Those Who Used It. Usage of traffic report may not be the best indicator of the utility of this function. For travel at off peak hours, or in rural areas, it is unlikely that users would desire this information. To put the usage in perspective, the questionnaire ratings of the traffic report feature were examined for only renters for whom in-vehicle logs verified that the feature had been used at least once. The results of this examination are shown in table 33. For the item "The TravTek system's 'Traffic Report' feature was useful," the anchors for one and six were "strongly disagree" and "strongly agree" respectively. For the latter three items in table 33,

the anchors for one and six were “none of the time” and “all of the time” respectively. The median response to all items was four or more. Thus, on average, those that used the traffic report feature gave it favorable ratings. The local user questionnaire did not include questions on the traffic report feature.

Table 33. Ratings of the traffic report feature by renters who used that feature at least once.

Question	Mean	LCL	UCL	N'
The TravTek system's TRAFFIC REPORT feature <i>was useful</i>	4.2	3.97	4.36	241
The TravTek system's TRAFFIC REPORT feature <i>functioned properly</i>	4.6	4.41	4.80	229
The TravTek system's TRAFFIC REPORT feature's <i>information was believable</i>	4.0	3.79	4.20	234
The TravTek system's TRAFFIC REPORT feature's <i>information was timely</i>	3.9	3.71	4.11	226

Summary The traffic report feature was not used frequently, however, those that used it generally reported it to be useful.

WHERE AM I. A WHERE! AM I button on the steering wheel hub was always available for use by N and N+ users. When pressed, this button caused a synthesized voice message that gave the vehicle's current position in terms of heading, current street name, and the name of the next intersecting street. It was not necessary to enter a destination to use this function.

Renters. Of the 1,334 N+ and N mode renters for whom in-vehicle log data are available, 1,220, or 91 percent used the WHERE AM I function at least once. The function was used a total of 26,714 times for an average of 1.16 times per trip. There were no significant differences in usage between N+ and N renters.

Local Users. Preliminary analyses of local user data showed that availability of real-time traffic information (N+ compared to N) had no effect on use of the WHERE AM I function. In-vehicle logs of WHERE AM I use were available for 43 local users. All used the WHERE AM I function at least once with-and at least once without---installed routes. For the first month of their TravTek experience, in-vehicle logs were available for 38 local users. During that first month, 37 locals used the WHERE AM I function at least once, and 1 driver did not use it. During their second month, 3 of 38 locals did not use WHERE AM I. Table 34 shows WHERE AM I usage by locals as a function of month. It can be seen that WHERE AM I was used approximately twice as often during the first month as during the second month, and that usage was twice as high when a route was planned. Both the main effect of experience (first month vs. second month) ($F = (1, 33) = 24.46, p < 0.01$) and trip planning (planned trip installed vs. no planned trip) ($F = (1, 33) = 8.61, p < 0.01$), were statistically reliable. The interaction of experience and trip planning ($F = (1, 33) = 10.22, p < 0.01$), was also reliable. The interaction is the result in a decrease in the difference between planned trip installed and not installed trips as a function of experience.

Table 34. Proportion of local users who pressed the WHERE AM I button and the mean number of button presses per trip.

	<i>First Month</i>		<i>Second Month</i>	
	<i>Planned Route Installed</i>	<i>No Planned Route</i>	<i>Planned Route Installed</i>	<i>No Planned Route</i>
Proportion Who Used WHERE AM I	0.95	0.95	0.87	0.82
Mean Uses Per Trip	0.44	0.16	0.22	0.12

Where Am I Ratings Among Those Who Used It. Whereas renters and locals used the WHERE AM I function infrequently, infrequent usage should not be taken as a metric for the usefulness of this function. As can be seen in table 35, among those who used the WHERE AM I function, as verified by in-vehicle log records, questionnaire ratings were positive.⁶ Anchors for the first two items in the table were, one, “Strongly disagree,” and, six, “Strongly agree.” Anchors for the timeliness item were, one, “None of the time,” and, six “All of the time.” To be included in table 35, both in-vehicle log records and questionnaire responses had to be available for the same participants. Local user ratings of the WHERE AM I feature did not vary significantly as a function of month of use. Therefore the decline in use of the WHERE AM I function should not be viewed as a decline in the perceived value of this function.

Table 35. Questionnaire ratings of the WHERE AM I feature by renters and local users that used the function.

<i>Question</i>	<i>Renters</i>				<i>Local Users</i>			
	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
The TravTek system’s WHERE AM I feature was useful .	4.9	4.74	4.98	611	5.3	4.91	5.67	31
The TravTek system’s WHERE AM I feature functioned properly	4.9	4.78	5.02	600	5.2	4.79	5.68	30
The TravTek system’s WHERE AM I feature’s information was timely	4.7	4.64	4.89	596	5.1	4.66	5.53	31

Summary. The majority of renters and local users made use of the WHERE AM I function. Although use was infrequent, among those that used the function, ratings of usefulness and timeliness were favorable.

Learnability. The ease of learning to use the TravTek system is evaluated using questionnaire data.

Renters. Overall, rental users reported that the TravTek systems drive functions and features were easy to learn. Table 36 provides a summary of the rental users’ agreement with the assertion that

⁶ Among users for whom the in-vehicle log records show no evidence of WHERE AM I function use, questionnaire ratings of the function were neutral to negative.

the listed items “easy to learn.” For all the items, one represented “strongly disagree” and six represented “strongly agree.” Multivariate analysis of variance revealed no significant differences between N+ and N configuration user ease of learning ratings. Therefore, the data in table 36 were pooled from the responses of both groups. Items that refer to traffic information and traffic report are from N+ respondents.

Table 36. Renters’ agreement with the assertion that TravTek functions and features were easy to learn.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
Overall, the TravTek system	5.2	5.17	5.26	1680
The TravTek system’s Guidance Display	5.4	5.39	5.48	1504
The TravTek system’s Route Map	5.4	5.34	5.44	1323
The TravTek system’s “Voice Guide” feature	5.5	5.43	5.52	1401
The TravTek system’s technique of displaying a local map for driving without a pre-selected destination.	5.4	5.54	5.46	1316
Overall, the steering wheel buttons	5.4	5.33	5.43	1513
The TravTek system’s OK new route feature	5.5	5.44	5.52	1495
The TravTek system’s WHERE AM I feature	5.6	5.58	5.65	1261
The TravTek system’s REPEAT VOICE feature (“The last message was...”; button located on steering wheel)	5.7	5.64	5.71	1118
The TravTek system’s “Hop Right/Hop Left” feature	5.0	4.90	5.07	836
The TravTek system’s TRAFFIC REPORT feature	5.6	5.50	5.63	565
The TravTek system’s technique of displaying updated traffic conditions on the Route Map	5.0	4.91	5.11	1096
The TravTek system’s technique of displaying updated traffic conditions on the Guidance Display	5.3	5.20	5.37	610

Local Users. Local users’ assessment of ease of learning is summarized in table 36. These data are from the questionnaire given following the first month of TravTek use, except that the traffic report and traffic information data are from whichever questionnaire followed the users’ N+ experience. It can be seen that the local user ratings were higher than those from renters, but that the response pattern of the two user groups is otherwise very similar.

Table 37. Local users' agreement with the assertion that TravTek functions and features were easy to learn.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
Overall, the TravTek system	5.6	5.40	5.80	50
The TravTek system's Guidance Display	5.8	5.73	5.95	50
The TravTek system's Route Map	5.6	5.43	5.83	49
The TravTek system's Voice Guide feature	5.8	5.66	5.94	50
The TravTek system's technique of displaying a local map for driving without a pre-selected destination.	5.8	5.24	6.36	5
The TravTek system's steering wheel buttons	5.5	5.20	5.80	50
The TravTek system's OK new route feature	5.8	5.64	5.92	50
The TravTek system's WHERE AM I feature	5.8	5.72	5.94	48
The TravTek system's REPEAT VOICE feature	5.8	5.66	5.97	43
The TravTek system's Hop Right/Hop Left feature	5.4	5.09	5.81	29
The TravTek system's TRAFFIC REPORT feature	5.3	4.78	5.78	25
The TravTek system's technique of displaying updated traffic conditions on the Route Map	5.3	4.91	5.65	25
The TravTek system's technique of displaying updated traffic conditions on the Guidance Display	5.4	4.88	5.83	25

Summary. TravTek users found the system to be easy to learn,

Usability and Understandability. TravTek users were asked to rate the usability of the system and its features. For this analysis responses to the assertion that specified function was "easy to use" or "easy to understand" are reported.

Renters. Mean ratings for renters are shown in table 38. All items in table 38 were responses to the "Easy to use" assertion unless understandability is indicated. For all items the anchors were one, "strongly disagree," and six, "strongly agree." On average, renters judged the system easy to use and understand.

Local Users. As can be seen in table 39, local users also tended to agree with the assertion that the TravTek system and its drive functions and features were easy to understand and, or, use. The data shown in table 39 are computed from averages of users' responses to the first and second month questionnaires, with the exception of the traffic report and traffic information items which are from the N+ month.

Table 38. Rental user ratings of TravTek's usability and understandability.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
Overall, the TravTek system was understandable	5.2	5.18	5.27	1539
The TravTek system's Guidance Display	5.4	5.34	5.43	1498
The TravTek system's Route Map	5.3	5.25	5.34	1188
The TravTek system's technique of displaying a local map for driving without a pre-selected destination.	5.5	5.44	5.54	1188
The TravTek system's Voice Guide feature	5.6	5.51	5.59	1355
Overall, the steering wheel buttons	5.4	5.40	5.48	1515
The TravTek system's SWAP MAP feature	5.5	5.45	5.56	1064
The TravTek system's OK New Route feature	5.4	5.37	5.47	1322
The TravTek system's WHERE AM I feature	5.6	5.60	5.67	1259
The TravTek system's REPEAT VOICE feature	5.7	5.63	5.70	1119
The TravTek system's Hop Right/Hop Left feature----- understandability	4.9	4.82	5.00	836
The TravTek system's TRAFFIC REPORT feature----- usability	5.6	5.53	5.65	564
The TravTek system's TRAFFIC REPORT feature---- understandability	5.2	5.14	5.32	561
The TravTek technique of displaying updated traffic conditions on the Route Map	4.8	4.74	4.95	633
The TravTek system's technique of displaying updated traffic conditions on the Guidance Display	5.3	5.16	5.34	607

Table 39. Local user ratings of TravTek's usability and understandability.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
Overall, the TravTek system was understandable	5.6	5.36	5.82	51
The TravTek system's Guidance Display	5.7	5.56	5.84	51
The TravTek system's Route Map	5.6	5.48	5.81	50
The TravTek system's Voice Guide feature	5.6	5.34	5.83	31
The TravTek system's technique of displaying a local map for driving without a pre-selected destination	5.8	5.40	6.26	6
The TravTek system's steering wheel buttons	5.6	5.37	5.77	51
The TravTek system's SWAP MAP feature	5.7	5.54	5.84	50
The TravTek system's OK new route feature	5.7	5.58	5.85	51
The TravTek system's WHERE AM I feature	5.7	5.48	5.89	30
The TravTek system's REPEAT VOICE feature	5.8	5.64	5.90	47
The TravTek system's Hop Right/Hop Left feature---- understandability	5.5	5.23	5.83	35
The TravTek system's technique of displaying updated traffic conditions on the Guidance Display--- Understandability	5.2	4.73	5.61	41
The TravTek system's technique of displaying updated traffic conditions on the Route Map---Understandability	5.3	4.97	5.66	41
The TravTek system's TRAFFIC REPORT feature--- usability	5.4	4.93	5.81	27
The TravTek system's TRAFFIC REPORT feature---- understandability	5.2	4.73	5.72	27

Summary. Both renters and local users rated usability positively. It may be interesting to note that both groups gave the lower positive ratings to traffic information related features. Unfortunately, with the available data it is not possible to distinguish whether these ratings reflect reactions to the method of presenting the traffic information, or to the information itself. Problems with the quality of the traffic information have been noted in the TravTek Evaluation Architecture Study final report.“

Preferences for Features Available When the Vehicle is Parked. The following sections examines drivers’ preferences for, and use of selected TravTek features and functions that were available only when the vehicle was in PARK: Three features are examined from both the perspective of stated preferences in the questionnaires, and actual use as recorded in the in-vehicle data log. These features are: (1) use of the HELP function, (2) use of the help desk feature, and (3) preferences for choices of routing methods (i.e., fastest, avoid tolls, and avoid Interstates). Questionnaire ratings of other non-drive features and functions are also reported.

Although all driver interactions with the TravTek system were recorded in the in-vehicle log, only those of greatest potential interest were selected for inclusion in this report. Use of the HELP function is of interest because it provides another perspective on ease of use, and, perhaps, may suggest the relative importance of providing HELP functions.

The AAA provided 24-h help desk assistance to TravTek users. The help desk phone number was prominently displayed on the center console of all the vehicles so that users could call by dialing the cellular phone in the vehicle or dial from any phone. However, the help desk could also be reached from TravTek help screens. Only calls made from TravTek help screens were recorded in the in-vehicle data log and are examined here.

The TravTek system offered three routing methods to drivers using it to plan trips. The frequency that renters and locals selected the three routing methods are examined and compared.

HELP function. All non-drive TravTek screens shown on the vehicle information center video display had a touch sensitive HELP button in the upper left hand corner. An example of the HELP button may be seen in figure 14 on page 63. Pressing the help button brought up a help menu as depicted in figure 11. Selecting the SCREEN INSTRUCTIONS button lead to one or more text screens with instructions on use of the system. Pressing the EMERGENCY HELP button brought up a choice of “police/fire/medical,” “road service,” and “cancel.” Pressing PHONE TO HELP DESK would place a call to the TravTek help desk. The use of the help desk function is discussed in the section that follows.

Renters. Help button press data were available for 1,325 rental units.⁷ Drivers of those units pressed the help button a total of 6,964 times. N+ and N drivers pressed help roughly twice as often as drivers of S configured vehicles. N+ rentals each averaged 5.47 button presses, N rentals averaged 6.01 button presses and S rentals averaged 2.8 button presses. Table 40 shows the per-

⁷ Use of the term rental unit indicates data from one or more drivers from a single vehicle rental have been combined.

cent of rental units in each vehicle configuration whose use of the help function fell into one of four categories: (1) never, (2) once, (3) two to five times, and (4) more than five times.

It can be seen that the majority of N+ and N rentals used the help function more than once, whereas half of S rentals used the help function more than once. This should not be interpreted to mean that S drivers did not have a need for help with the TravTek system. There were 29,718 trips recorded in which the TravTek system was used. These “TravTek trips” were defined as trips during which the NAVIG button was pressed to activate the TravTek video displays, S rentals used the help system for a greater proportion of TravTek trips than did renters from the N+ and N groups. TravTek was used on 15,512 N+ trips, with a median of 22 TravTek trips per rental. TravTek was used on 12,587 N rental trips, with a median of 17.5 TravTek trips per rental. TravTek was used on 1,619 S rental trips, with a median of 6 TravTek trips per rental. On average, S rentals pressed a help button on 35.1 percent of their TravTek trips, whereas on average N+ and N rentals used the help button on 26.8 and 27.6 percent of their trips respectively. Therefore it appears that whereas the S rentals were less likely to use TravTek on any particular trip, they were at least as likely as drivers with the other configurations to use the help function when they did use the TravTek system.

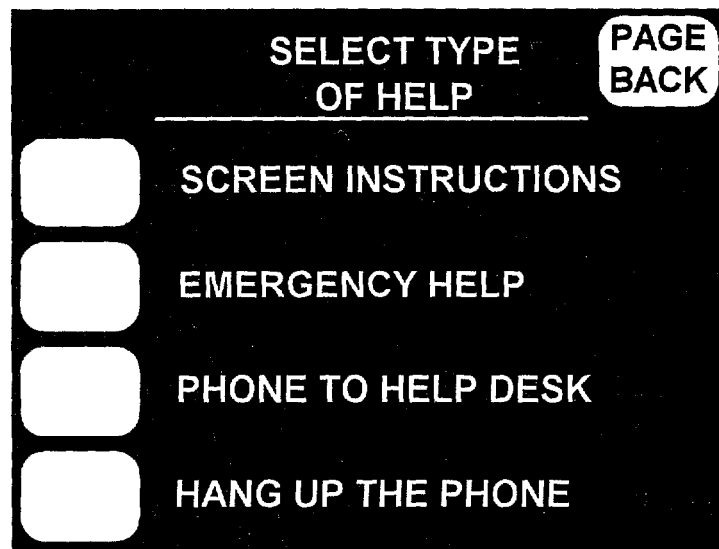


Figure 11. An example of main help screen from which help on all screens could be obtained.

Table 40. Rental driver use of the TravTek system’s HELP key function.

<i>Frequency of Help Key Use</i>	<i>Vehicle Configuration</i>		
	<i>N+</i>	<i>N</i>	<i>S</i>
Never	10.4 %	9.7 %	32.4 %
Once	13.0 %	9.5 %	18.3 %
Two to Five Times	39.7 %	38.7 %	33.4 %
More than Five Times	36.9 %	42.1 %	15.9 %
Rentals in Sample	624	494	207

Local Users. In-vehicle log data on help usage for both first and second month were available from 34 local users who made 7,483 TravTek trips. A TravTek trip included all cases for which

the engine was started and the NAVIG button that accessed the TravTek system was pressed. Table 41 shows a breakdown of local user help function usage. Twenty-four of the local users pressed the HELP key more than five times during their first month of use. Twenty-seven local users pressed the help key at least once during the second month of use. Thus most locals made more than incidental use of the help function and continued to use it at least occasionally throughout their TravTek experience.

Table 41. Locals' use of the TravTek system's HELP key function.

<i>Frequency of Help Key Use</i>	<i>Vehicle Configuration</i>	
	<i>First Month</i>	<i>Second Month</i>
Never	8.8 %	20.6 %
Once	3.0 %	8.8 %
Two to Five Times	17.6 %	38.2 %
More than Five Times	70.6 %	32.4 %
Locals in Sample	34	34

Although the average local user pressed the HELP key many more times than the average renter, it should be noted that on a per trip basis, locals did not use the help function more than renters — local users took many more trips and therefore had many more (over 200 more on average) opportunities to use help.

Questionnaire Findings. Whereas the in-vehicle data log shows how often the help function was used, the questionnaires can show what users said they thought about the help function. Users were excluded from the questionnaire analysis if the in-vehicle log suggested they did not use the help function. Users for whom in-vehicle logs were not available were included. No significant differences between N+, N or S configuration drivers were identified in help function ratings. Shown in table 42 are summaries of responses regarding the help feature itself, the text instructions that could be accessed from the main help screen, and the emergency services feature that was also accessed from the main help screen. For all of the questions the anchors were one, “strongly disagree,” and six, “strongly agree.” Rental users were generally positive about the help features and all ratings were well above the neutral point of 3.5.

Table 43 shows local users' ratings of the help system following the second month of their participation. Because local users who participated during the early part of the operational test received an abbreviated questionnaire, ratings of the help system are for only 30 of the 51 local users. Eight local users said they did not use the help system and therefore did not rate it. Whereas the help system questions were omitted from early questionnaires, all local users were questioned about the on-screen instructions. Eighteen of the fifty one said they did not use the on-screen instructions. Local users were not asked to rate the emergency services feature.

Table 42. Rental user responses to questionnaire item concerning the TravTek system's help function and selected sub-functions.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
The TravTek system's help feature was easy to learn	5.3	5.19	5.31	929
The TravTek system's help feature was easy to use	5.1	5.08	5.22	920
The TravTek system's help feature was useful	4.6	4.51	4.70	913
The TravTek system's on-screen instructions were easy to learn	5.3	5.28	5.39	968
The TravTek system's on-screen instructions were easy to use	5.3	5.22	5.34	961
The TravTek system's on-screen instruction were useful	4.8	4.72	4.88	953
The TravTek system's emergency services feature was easy to learn	5.4	5.20	5.61	101
The TravTek system's emergency services feature was easy to use	5.3	4.99	5.51	92
The TravTek system's emergency services feature was useful	4.6	4.24	5.01	80
The TravTek system's emergency services feature offered timely assistance	4.6	4.17	5.07	61

Table 43. Local users' ratings of the TravTek help system and features accessed through the help system.

<i>Question</i>	<i>Mean</i>	<i>Min</i>	<i>Max</i>	<i>N'</i>
The TravTek system's help feature was easy to learn	5.6	3	6	22
The TravTek system's help feature was easy to use	5.6	2	6	22
The TravTek system's help feature was useful	5.3	2	6	21
The TravTek system's on-screen instructions were easy to learn	5.6	4	6	33
The TravTek system's on-screen instructions were easy to use	5.6	4	6	32
The TravTek system's on-screen instructions were useful	5.1	1	6	33
The TravTek system's on-screen instructions functioned properly.	5.5	3	6	30

Summary. Most rental and local users used of the system's help feature. Of those who used the feature, most rated it highly with respect to ease of learning, usability and usefulness.

Help Desk Calls. One of the Help screen buttons placed a call to the TravTek Help Desk which was part of the TISC. The TISC was staffed around the clock, 7 days a week by AAA personal.

In-Vehicle Logs. Table 44 provides a breakdown of frequency of calls to the help desk made by rental users as recorded in the in-vehicle log. Table 45 shows the number of local users making use of the help desk as a function of the number of calls made, also as recorded in the in-vehicle log. It should be noted that the Help Desk phone number was conspicuously posted on the center console of most of the TravTek vehicles. Calls made be manually dialing the posted number werenot recorded in the in-vehicle data log; only calls made from the Help Screen menu were logged in the vehicle. It should also be noted that the help desk operators called every TravTek renter mid-

way through the rental period. The number of help desk calls may have been reduced somewhat because of help given during the mid-rental interviews.

Approximately 70 percent of N+ and N rental users never called the help desk through the TravTek system. As a group, S drivers were the least likely to call the help desk. With the exception of two drivers, local users rarely called the help desk.

Table 44. Percent of rental users that called the Help Desk.

<i>Frequency of Calls to the Help Desk</i>	<i>Vehicle Configuration</i>		
	<i>N+</i>	<i>N</i>	<i>S</i>
Never	71.5 %	69.7 %	85.2 %
Once	12.1 %	12.7 %	8.3 %
Two to Five Times	12.9 %	14.1 %	6.5 %
More than Five Times	3.5 %	3.5 %	0.0 %
Rentals Units in Sample	736	607	216

Table 45. Percent of local users that called the Help Desk.

<i>Frequency of Calls to the Help Desk</i>	<i>Vehicle Configuration</i>	
	<i>First Month</i>	<i>Second Month</i>
Never	81.8%	94.2%
Once	12.2%	0%
Two to Five Calls	3.0%	2.9%
More than Five Calls	3.0%	2.9%
Local Users in Sample	33	34

Questionnaires. Table 46 shows the questionnaire ratings of the Help Desk that were provided by TravTek rental users. For all questions, the anchors were one, “strongly disagree,” and six, “strongly agree.” The table excludes users whose in-vehicle logs indicate that they did not use the help desk function, but includes users for whom in-vehicle logs were not available.

There were no statistically reliable differences in Help Desk ratings as a function of vehicle configuration. Therefore the data shown in table 46 summarize responses without regard to vehicle configuration. The Help Desk received positive ratings from TravTek rental users.

Table 46. TravTek rental user responses concerning the TravTek Help Desk.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
The TravTek system's Help Desk was available	5.5	5.39	5.56	683
The TravTek system's Help Desk was easy to use	5.4	5.32	5.48	675
The TravTek system's Help Desk was useful	5.3	5.20	5.39	663
The TravTek system's Help Desk Correctly answered questions in a timely manner	5.3	5.19	5.37	658

Table 47 summarizes local user ratings of the Help Desk. The ratings are from the second month questionnaire, for which 32 respondents' questionnaires were available. Nine of the thirty two local users said they did not use the help desk. The remainder of the local users gave the help desk

ratings very similar to those of rental users. The item “The TravTek system’s Help Desk was available” was only included in the questionnaires of three local users.

Because of the already small sample size, and because it was possible to call the Help Desk without using the TravTek system, local user use of Help Desk was not verified in the in-vehicle log.

Table 47. TravTek local user responses concerning the TravTek Help Desk.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
The TravTek system’s Help Desk was available	6.0			3
The TravTek system’s Help Desk was easy to use	5.6	5.25	5.87	23
The TravTek system’s Help Desk was useful	5.5	5.01	5.95	23
The TravTek system’s Help Desk Correctly answered questions in a timely manner	5.1	4.48	5.70	23

Summary. Many TravTek users may never have called the Help Desk. However, those who did, or said they did, reported the Help Desk to be useful.

Destination Entry. ENTER DESTINATION was a choice available from the main TravTek menu. The destination entry screen offered five ways to enter a destination:

- From a list of saved destinations.
- From the Services and Attractions Directory.
- By entering a complete address (street name and number).
- By entering an intersection (two street names).
- By entering just the street name.

The destinations in the saved list were initially entered by one of the other four methods. Figure 12 shows the mean percent of trips each method was used for 698 N+ renters, and 558 N renters. The Services and Attractions Directory was used by renters approximately half the time. Selection from the saved list, was the next most frequently used method. The rental users, who were mostly visitors unfamiliar with the Orlando area, seldom entered streets, addresses, or intersections as a destination.

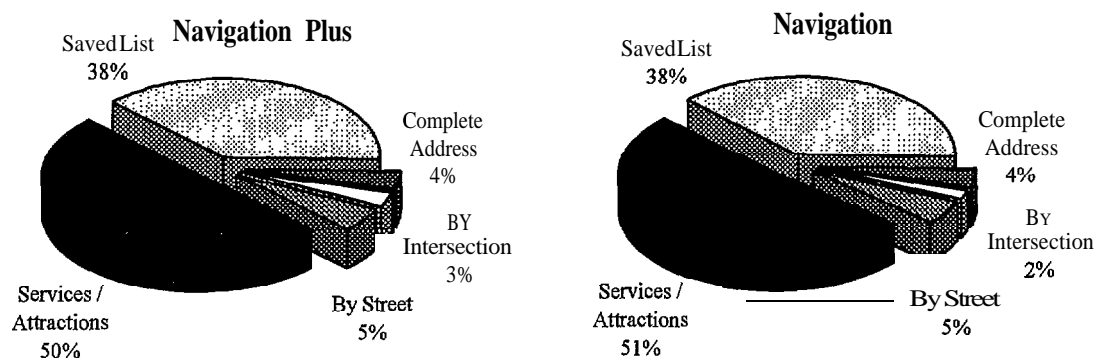


Figure 12. Methods of selecting destinations used by renters.

The usage of the five destination entry methods by local users is shown in figure 13. The data shown are from 40 and 37 local users with N+ and N configurations respectively, for whom in-vehicle logs were available. Unlike renters, local users often entered destinations using a complete address, street name, or intersection name. After they had entered a destination once, local users tended to use the saved list the next time they traveled to that destination. Local users and renters used the save list about equally often — about 40 percent of the time. Very unlike the renters, the local users seldom selected destinations from the Services and Attractions Directory. It should be remembered that the TravTek Services and Attractions Directory was tailored to the needs of tourists. Had a larger directory, with more categories and more services likely to be of use to local resident been available, the local user findings might have been different.

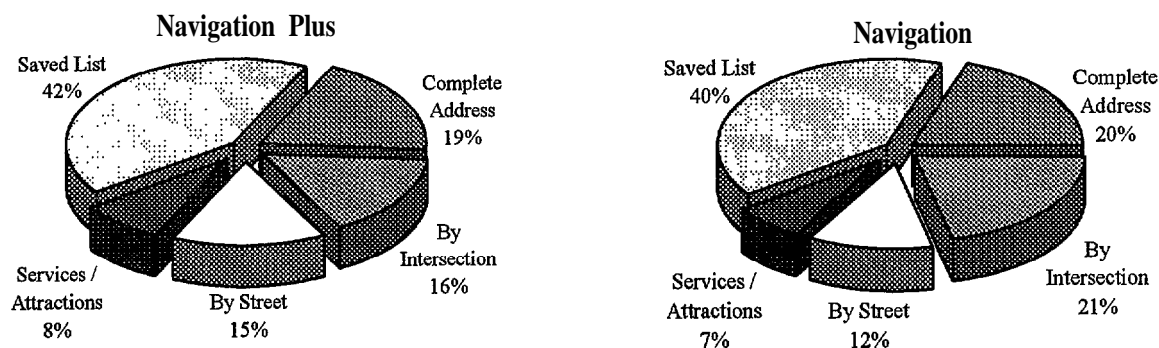


Figure 13. Methods of selecting destination used by local users,

Summary. The Services and Attractions Directory was frequently used by visitors. The saved destination list, as judged by usage, proved valuable to both visitors and local users. Local users made frequent use of the touch screen keyboard to enter streets, intersections, and addresses as destinations.

Routing Method. After a destination was selected, the TravTek system presented the user with three route selection criteria: fastest, avoid Interstates, and avoid toll roads. If the user selected one of the latter two options the system would plan a trip that did not use, if possible, the road type to be avoided. An example of the routing method selection screen is shown in figure 14.

No differences were detected between the routing method preferences of N+ and N renters, so the results reported here are pooled from both groups. The findings shown in figure 15 are based on 15,320 trips for which 1,077 renters used TravTek to plan their routes. Renters usually selected the routing method that yielded the fastest trip, but occasionally chose to avoid tolls. Only rarely did renters choose to avoid Interstates.

For local users there were no statistically reliable differences in routing method selection preference either between the first and second month or between N+ and N configurations. The mean percent each method was selected is shown in figure 16. The data in figure 16 represent 4,370 local user trips, averaged over 34 local users for whom in-vehicle logs were available for both the first and second month of use.

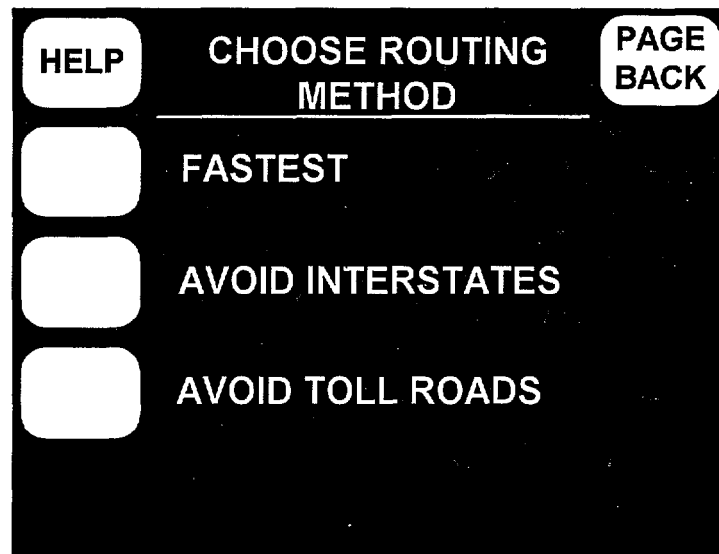


Figure 14. An example of routing method selection screen,

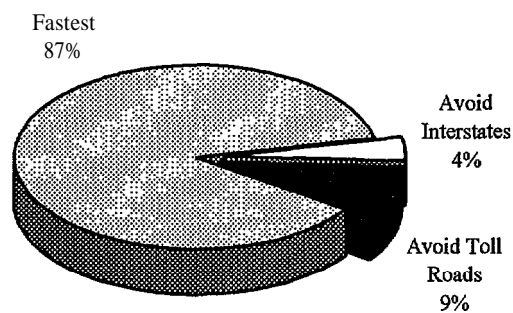


Figure 15. Renters' mean percent selection of each routing method.

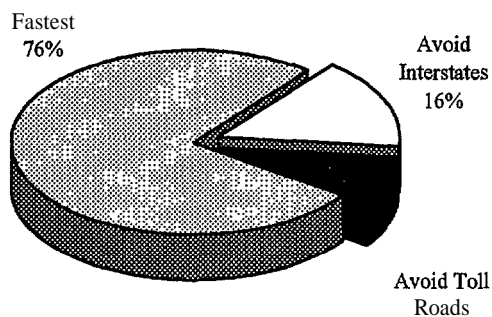


Figure 16. Local users' mean percent selection of each routing method.

Whereas most users, both locals and renters, chose the fastest method most of the time, users in both groups rated the routing choice screen favorably. Users perceived the feature as useful, pro-

viding the desired options, and helpful in route planning. Mean questionnaire ratings of the routing screens are shown in table 48 for renters and table 49 for local users.

Table 48. Rental driver ratings for the routing method choice screen.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
The TravTek system's screen for choosing the routing method was useful.	5.0	5.36	5.45	1492
The TravTek system's screen for choosing the routing method provided desired choices	5.1	5.05	5.17	1485
The TravTek system's screen for choosing the routing method helped me plan my trip.	5.2	5.16	5.27	1482

Table 49. Local user ratings for the routing method choice screen.

<i>Question</i>	<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
The TravTek system's screen for choosing the routing method was useful.	5.0	4.72	5.37	51
The TravTek system's screen for choosing the routing method provided desired choices.*	4.7	4.20	5.25	29
The TravTek system's screen for choosing the routing method helped me plan my trip	5.0	4.72	5.38	51

*This question omitted from early version of local driver questionnaire.

In summary, the pattern of usage of the three point suggest that both renters and locals was similar. Both groups selected fastest for the majority of trips. Rental users rarely selected avoid Interstates but local users selected avoid Interstates about 16 percent of the time. All users were favorable towards having a choice of routing methods.

How Much are Drivers Willing to Pay for TravTek Features/Capabilities?

The questionnaire ratings presented to this point suggest that both renters and local users perceived TravTek to help them to find their way, save time, drive more safely, and feel more secure while driving. Users also said that the TravTek system was useful, easy to use, and functioned properly. The in-vehicle data suggest that renters and local users used the system for many of their trips. Another key question, that is important to the fielding of ITS systems, is whether users find the systems useful enough to purchase in quantities that would support such ITS goals such as improved network efficiency and decreased navigational waste. In this section the amount of money TravTek users indicated they would pay for the TravTek system and its components is reviewed. The data come from the questionnaires.

Four sets of questions addressed willingness-to-pay:

1. The amount participants would be willing to pay for a system such as the one they drove.
2. The amount participants would be willing to pay for TravTek features as options on a new car.

3. The amount participants would be willing to pay for TravTek features as add-ons to an existing car.
4. The amount participants would be willing to pay for TravTek features in a rental car.

Responses to the willingness-to-pay questions were indicated by placing an *X* on a line that had tick marks representing dollar values at equally spaced intervals. Figure 17 provides an example of a willingness-to-pay scale that was used in the questionnaires.



Figure 17. An example of a willingness-to-pay scale.

The first of the willingness-to-pay questions asked respondents to estimate how much they would pay, in dollars, for a system such as the one they had just experienced. For that question, it would be expected that renters who drove the S configuration vehicles (which had a services and attractions directory, but did not have route planning, route guidance, or traffic information functions) would not be willing to pay as much as those who had the more fully featured N or full featured N+ configurations.

Renters — System Such As the One They Drove. There were significant differences between the means among renters from the three configurations ($F(2, 1607) = 11.36, p < 0.001$). Rental users' willingness-to-pay for a TravTek system "Such as you drove" findings are depicted in figure 18. The vertical axis shows the percentage of renters that were willing to pay the indicated amount or more. For instance, 100 percent of the users indicated they would pay zero dollars or more, and 50 percent of S respondents were willing to pay \$500 or more. It can be seen that between N+ and N renters there was no significant difference in willingness-to-pay, and that 50 percent of respondents from those configurations were willing to pay \$1,000 or more. The vertical axis is labeled "Percent market penetration" under the assumption that renters' estimates of what they would be willing to pay reflect the price point at which they, and the general public, would actually purchase a system. This assumption is probably optimistic given that additional factors besides perceived worth are involved in purchase decisions. The 50 percent line drawn in figure 18 indicates median willingness-to-pay. Because the data are positively skewed (i.e., a few respondents selected the maximum possible value of \$4,000) the median is probably the better indicator of the "average" response than the mean.

The apparent lack of a difference in willingness-to-pay expressed between N+ and N configuration renters may suggest no perceived added value for real-time traffic information. There are several reasons why this should not be taken as an indication that motorists would not perceive a value for traffic information: (1) as will be shown in the paragraphs that follow, a substantial proportion of renters indicated that they would be willing to pay for real-time information, (2) there were problems, detailed in the *TravTek System Architecture Evaluation*, with the real-time information provided by TravTek, and (3) the renters in this study may not have driven in areas where congestion could be avoided.⁽⁹⁾

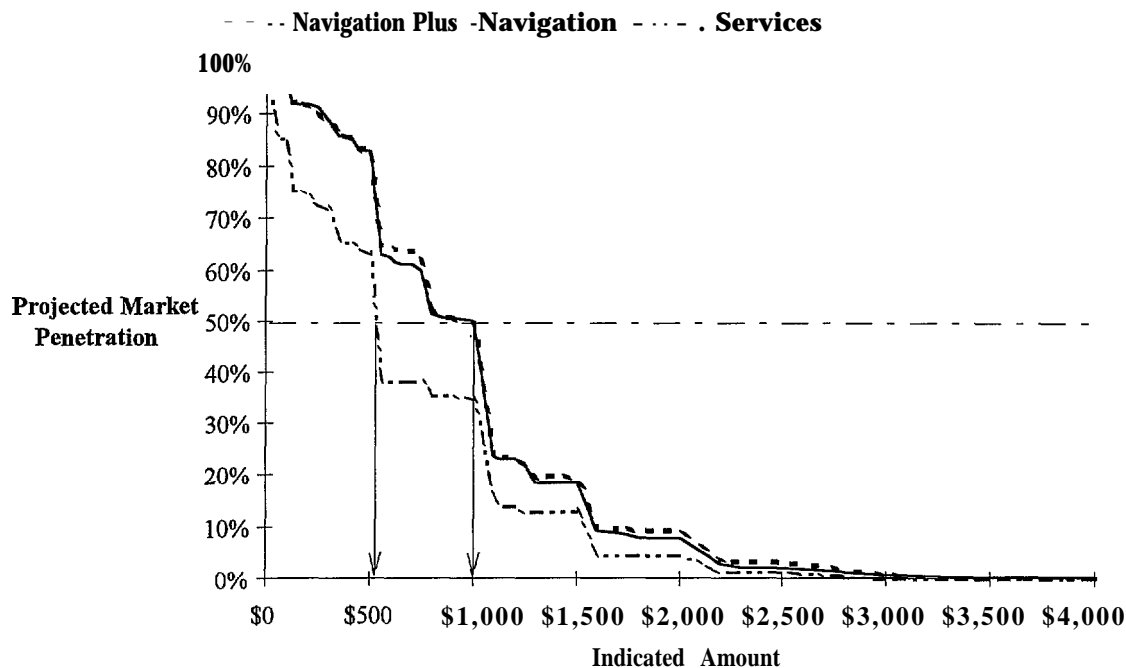


Figure 18. Cumulative willingness-to-pay indicated by renters for a TravTek system such as the one they drove.

Local Users -System Such As the One They Drove. As can be seen in figure 19, local users' estimate of willingness-to-pay was very similar to that of renters. Among local users, no reliable difference in willingness-to-pay was found between first and second month estimates, or between estimates following N+ or N driving experiences. Therefore the data depicted in figure 19 represent the average of both estimates from the 51 local users.

Summary. The data from both renters and local users suggest that a substantial market penetration could be achieved for TravTek-like systems priced around \$1,000.

Willingness to Pay for TravTek Features. Whereas the first questionnaire item asked how much respondents would pay for a system such as the one they drove, the latter three questions ask how much they would pay for TravTek features in new cars, as add-ons, and in rental cars. The features were briefly described and renters from all three vehicle configuration groups were asked about all features. Table 50 provides a summary of renter responses to the willingness-to-pay for features questions. The features queried were navigation only (e.g., a map without routing), route guidance only, and up-to-date traffic information only. There were no statistically reliable differences between mean estimates of willingness-to-pay as a function of vehicle configuration. Therefore, the mean willingness-to-pay estimates shown in table 50 were computed without regard to vehicle configuration.

The finding that the vehicle configuration users experienced did not significantly influence estimates of the value of features is interesting, as it implies that willingness-to-pay estimates are not influenced by degree of actual experience with features. An extension of this implication is that future ITS operational tests may not need to provide users with hands on experience to obtain

willingness-to-pay estimates. However, there are several reasons to caution against this interpretation: (1) the TravTek questionnaire items on features did not ask about the value of the features as experienced, but rather, asked users to imagine an ideal system; (2) to the extent that users allowed their system experience to influence their estimates, there may have been complex interactions specific to the TravTek experience; and, (3) the present findings may be specific to the way in which the questions were presented, such that other methods of presentation might yield variations due to experience. The first explanation, that drivers from all three configurations imagined similar systems, suggests that users can separate imagination from experience, but does not tell us what the results might have been had Navigation Plus users been asked, for instance, how much they would pay for real-time traffic information such as they received in their visit to Orlando. The second explanation suggests that users who had experienced features would have valued the features differently than those who did not if the TravTek experience had been different; that similarity in willingness-to-pay estimates across configurations was the result of TravTek specific experience. The third explanation suggests that the present results are due to specific attributes of the TravTek questionnaire. Therefore, whereas the present findings are consistent with the assertion that degree of actual system experience does not influence willingness-to-pay estimates, the evidence is certainly not conclusive.

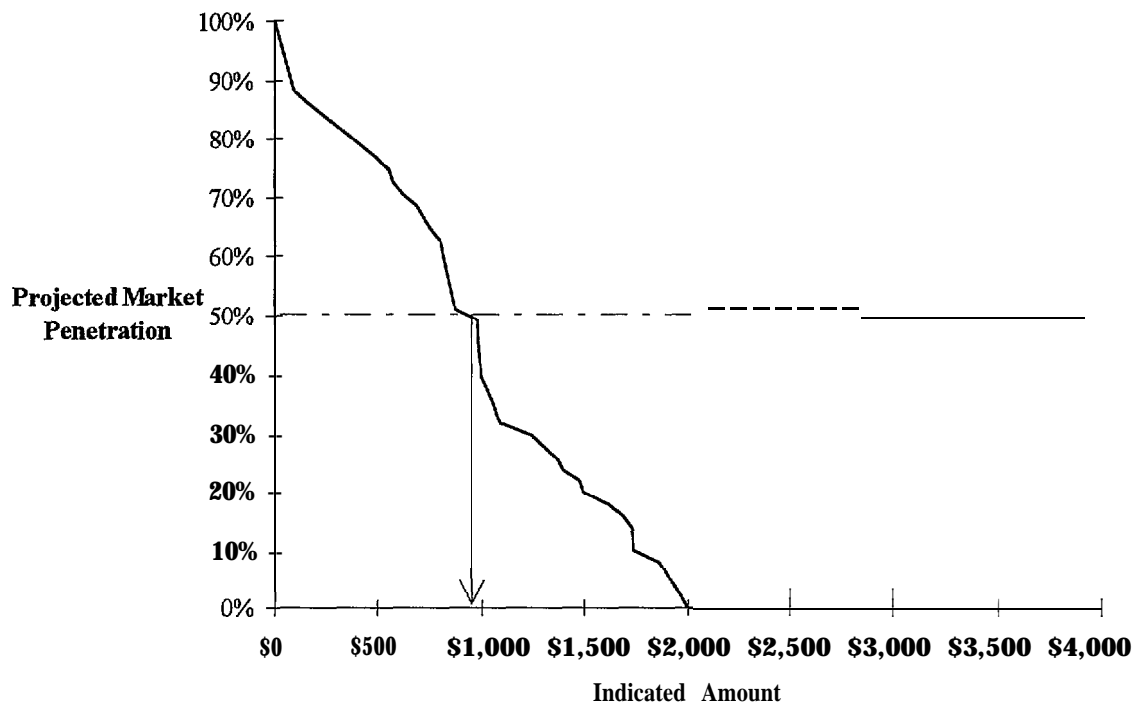


Figure 19. Cumulative willingness-to-pay indicated by local users for a TravTek system such as the one they drove.

Table 50. Rental respondents' mean estimated willingness-to-pay for TravTek features.

<i>Question</i>	<i>Scale Range:</i>	<i>Mean</i>
How much would you be willing to pay for the following features <u>as separate options in a new car?</u>		
1. Services/Attractions Directory Only	\$0 - \$2500	\$199
2. Navigation Only	\$0 - \$2500	\$394
3. Route Guidance Only	\$0 - \$2500	\$402
4. Only Up-To-Date Traffic Information	\$0 - \$2500	\$294
Total TravTek With All Features	\$0 - \$4000	\$1021
How much would you be willing to pay for the following features <u>as an add-on to any car?</u>		
1. Services/Attractions Directory Only	\$0 - \$2500	\$169
2. Navigation Only	\$0 - \$2500	\$335
3. Route Guidance Only	\$0 - \$2500	\$345
4. Only Up-To-Date Traffic Information	\$0 - \$2500	\$253
Total TravTek With All Features	\$0 - \$4000	\$925
How much <u>extra per week</u> would you be willing to pay for the following features <u>as an option on a rental car?</u>		
1. Services/Attractions Directory Only	\$0 - \$25	\$8
2. Navigation	\$0 - \$25	\$11
3. Route Guidance	\$0 - \$25	\$12
4. Up-To-Date Traffic Information	\$0 - \$25	\$8
Total TravTek With All Features	\$0 - \$100	\$35

Renters. The mean estimate of the value of a services and attractions directory in a new car approached \$200, and was estimated to be worth \$169 as an add-on. The mean value of a services and attractions directory in a rental was \$8 per week. Renters expressed a willingness to pay about \$400 each for navigation and route guidance capabilities in a new car, about \$335 dollars as an add-on to an existing vehicle. The questionnaire may not have been as clear as possible in distinguishing between navigation and route guidance. The intent of the questionnaire was to associate navigation with the map that was available when a planned route was not installed, and therefore route guidance was not available. However, in contexts other than TravTek, route guidance would generally be considered a navigation function. The description of the navigation function ("Features to tell you where you are while driving to your destinations") may not have been perceived, by some users, as excluding route guidance. Therefore it is possible that the estimates for navigation assistance alone may be higher than they might have been had the description of the navigation function been more highly differentiated from route guidance.

Although renters indicated that real-time traffic information was not worth as much as route guidance, they still indicated they would pay a substantial amount for that information.

Local Users. Table 51 summarized local user estimates of willingness-to-pay for TravTek features. Because of the smaller sample size for local users, and hence the greater influence of extremely estimates, table 51 show medians rather than means. In general, the trend among local users is very similar to that seen among renters. That is, about half the respondents would pay at least \$400 for navigation or route guidance features in a new car-perhaps slightly more for route guidance-and about \$50 less for the same features as an add-on to a 1-week rental. Local users valued services and attractions in a new or used car much less than did the renters. However, local users valued services and attractions in a rental vehicle about the same as renters did. The TravTek Services and Attractions directory was tailored to be most useful to visitors, and this tailoring appears to be reflected in the differences in values estimated by the two user groups.

Table 51. Local user respondents' median estimated willingness-to-pay for TravTek features.

<i>Question</i>	<i>Scale Range:</i>	<i>Median</i>
How much would you be willing to pay for the following features <u>as separate options in a new car?</u>		
1. Services/Attractions Directory Only	\$0-\$25	\$125
2. Navigation Only	\$0-\$1000	\$400
3. Route Guidance Only	\$0-\$1000	\$400
4. Only Up-To-Date Traffic Information	\$0-\$1000	\$250
Total TravTek With All Features	\$0-\$2500	\$1200
How much would you be willing to pay for the following features <u>as an add-on to any car?</u>		
1. Services/Attractions Directory Only	\$0-\$25	\$100
2. Navigation Only	\$0-\$1000	\$350
3. Route Guidance Only	\$0-\$1000	\$363
4. Only Up-To-Date Traffic Information	\$0-\$1000	\$200
Total TravTek With All Features	\$0-\$2500	\$1200
How much <u>extra per week</u> would you be willing to pay for the following features <u>as an option on a rental car?</u>		
1. Services/Attractions Directory Only	\$0-\$25	\$9
2. Navigation	\$0-\$25	\$10
3. Route Guidance	\$0-\$25	\$10
4. Only Up-To-Date Traffic Information	\$0-\$25	\$5
Total TravTek With All Features	\$0-\$100	\$35

Summary. Both rental and local users indicated that navigation and route guidance features were worth more than traffic information. This trend help true for new, used, and rental vehicles.

Willingness-to-Pay as a Function of Income. To further explore the stated willingness-to-pay measures, renter willingness-to-pay was examined as a function of income. Three income categories were defined:

- Under \$40,000.
- \$40,000 through \$79,999.
- \$80,000 and over.

The willingness-to-pay data did not appear to derive from a normally distributed sampling population. In particular, for some questions, a substantial number of drivers indicated they would pay nothing (\$0). The means shown in table 50, above, include all respondents, including those who estimated that they would pay \$0. However, for the analysis of willingness-to-pay by income group, it was decided to exclude participants who indicated \$0.

Table 51 shows the proportion of renters, as a function of income, who indicated they would not pay for TravTek or its functions. A substantial minority were unwilling to pay for the Services and Attractions Directory feature in a new car or as an add-on. However, most renters rated the Services and Attractions Directory as worth paying for in a rental vehicle. Most renters were willing to pay for the route guidance and the navigation features, particularly when those features were on a new car or a rental car. There was greater resistance to paying for real-time traffic information, and this resistance approached 20 percent when offered as an add-on (not part of a new vehicle purchase). After excluding those who indicated that they would pay nothing, income group was found not to be a reliable predictor of the amount renters said they were willing to pay ($p > 0.05$).

As with renters, local users' income was not a reliable predictor of their willingness to pay ($p > 0.05$).

Summary. Half the participants in the renter and local user studies were willing to pay at least \$1,000 for a system similar to TravTek. Up to half that value derived from route guidance, and, perhaps, up to half from navigation capabilities. Real-time traffic information was valued at about half the estimated value of either navigation or route guidance features.

Where is TravTek Useful? Although local users and renters provided similar willingness-to-pay estimates, and both groups indicated navigation and route guidance functions were the most valuable TravTek functions, one still might suspect that the value of TravTek-like systems would be perceived as more valuable in some situations than others. Both rental and local users were asked whether they thought the TravTek system would be useful for business trips, vacations, and "at home" driving. The response alternatives were "yes" and "no." All the local users and 98 percent of the rental drivers thought that TravTek would be useful for vacation and business travel. Fifty-five percent of renters and 54 percent of the local users judged that TravTek would be useful for at home driving. Among both rental and local users, higher income drivers were significantly more likely to judge TravTek useful for at-home driving. Drivers 54 and younger were significantly more likely to judge TravTek useful for at-home driving. Less than 40 percent of drivers over age 54 thought TravTek would be useful at home.

The available evidence suggests that, initially, TravTek-like systems would be most marketable to drivers who frequently travel out of town, and to younger, more affluent drivers.

Does TravTek Enhance Trip and Network Efficiency?

Based on the pattern of TravTek usage demonstrated in other TravTek studies, the TravTek Modeling Study projected that, as market penetration increased, benefits to all drivers (not just TravTek users) would result in terms of reduced travel time, reduced fuel consumption, and reduced emissions.⁽⁸⁾ Small safety benefits were also projected.

Table 52. The proportion of renters, as a function of income group, who said they would pay nothing for the TravTek system or features of the TravTek system.

<i>Question</i>	<i>Household Income</i>		
	<i><\$40,000</i>	<i>\$40,000 <\$80,000</i>	<i>>\$80,000</i>
How much would you be willing to pay for a TravTek system such as the one you drove?	0.030	0.055	0.062
How much would you be willing to pay for the following features as separate options in a new car?			
1. Services/Attractions Directory Only	0.127	0.152	0.153
2. Navigation Only	0.041	0.058	0.062
3. Route Guidance Only	0.016	0.053	0.062
4. Only Up-To-Date Traffic Information	0.085	0.105	0.080
Total TravTek With All Features	0.109	0.008	0.013
How much would you be willing to pay for the following features as an add-on to any car?			
1. Services/Attractions Directory Only	0.230	0.281	0.264
2. Navigation Only	0.065	0.136	0.133
3. Route Guidance Only	0.048	0.125	0.125
4. Only Up-To-Date Traffic Information	0.134	0.181	0.153
Total TravTek With All Features	0.011	0.028	0.028
How much extra per week would you be willing to pay for the following features as an option on a rental car?			
1. Services/Attractions Directory Only	0.069	0.079	0.096
2. Navigation	0.040	0.047	0.046
3. Route Guidance	0.049	0.037	0.043
4. Only-Up –To-Date Traffic Information	0.162	0.115	0.098
Total TravTek With All Features	0.009	0.012	0.006
≈ Sample Size ¹	114	546	599

¹ Sample size varies slightly (±5 percent) for each question because of occasional failures to respond.

Given demonstrated and projected benefits of TravTek, it may be useful to compare users' perception of benefits. For this purpose two questionnaire items were examined:

- Do you think TravTek helped you avoid congestion?
- Do you think TravTek helped you save fuel?

Renters were asked both questions. Local users were only asked about fuel savings. The anchors for the congestion avoidance question were, one, "Didn't help avoid congestion at all," and six, "Helped avoid all congestion." The anchors for the fuel saving question were one, "Didn't help me save fuel," and six, "Helped me save more fuel" The findings are presented in table 53.

Although there were significant differences between N+, N, and S configuration drivers' perceptions with respect to congestion avoidance, the differences were in degree, not direction. All three groups agreed that TravTek did not help them avoid congestion. The N+ group, which was the only group that might have received a congestion avoidance benefit by design, was closest to neutral in its assessment; more N+ users perceived a benefit. It should be noted that drivers that avoided congestion might not have perceived this as they might be unaware of conditions on the roads they did not take.

The renters that had route planning and route guidance features were mildly positive in agreeing that TravTek helped them save fuel. As expected, S drivers did not, on average, perceive a fuel savings benefit. This finding suggests that some users with route planning and guidance features perceived that TravTek saved fuel.

There were no significant differences in local user ratings of fuel savings as a function of vehicle configuration or month. Therefore the average rating across both months is reported. Local users agreed with the assertion that TravTek saved fuel. Local users agreement that they saved fuel was about the same magnitude as that of renters with N+ and N configurations.

Table 53. Rental and local user perceptions of fuel savings and congestion avoidance.

<i>Question</i>		<i>Mean</i>	<i>LCL</i>	<i>UCL</i>	<i>N'</i>
<i>Renters:</i>					
Do you think TravTek helped you avoid congestion?					
	N+	3.3	3.14	3.36	834
	N	2.9	2.80	3.10	560
	S	2.0	1.75	2.21	132
Do you think TravTek helped you save fuel?					
	N+	3.7	3.56	3.77	899
	N	3.7	3.55	3.82	608
	S	2.5	2.06	2.85	77
<i>Local Users:</i>					
Do you think TravTek helped you save fuel?		3.9	3.51	4.24	51

Summary. TravTek users as a group did not perceive that TravTek helped them avoid congestion. Users that had route planning and route guidance did perceive that TravTek helped them save fuel.

Summary of Renter and Local User Open-Ended Comments on TravTek

A subset of rental users, and all local users, participated in semi-structured debriefings at the conclusion of their TravTek experience. Each debriefing participant was asked the same series of seven questions, thus providing some structure to the interviews. However, the participants were free to respond, or not respond, in any way they wished, and debrief followup questions were ad hoc. The seven questions that were asked for all debriefings were:

- “Overall, what impressions do you have about TravTek now that you’ve had a chance to ‘test drive the future?’”
- “What was your favorite feature?”
- “What was your least favorite feature?”
- “While driving with TravTek, were there any situations where TravTek was especially helpful?”
- “While driving with TravTek, were there any situations where TravTek was not helpful?”
- “Did the brochure, video, and orientation you were given prepare you for driving with TravTek?”
- “Can you think of anything that could be improved about TravTek to make it better?”

Because responses to the debriefing questions were open-ended, summarization of the responses required classification of the many responses into meaningful categories, or types. To this end, analysts read through debriefings from several hundred respondents, and for each debriefing question, created categories into which similar responses could be grouped. The summaries provided below are the work of several analysts, and include categories derived from several TravTek studies.⁸

The debriefing results are presented in table form. As can be seen in table 54, which summarizes responses to a question about overall impressions of TravTek, the tables are organized into four columns. The first column presents a short description of the categories identified by the analysts. A short descriptive name, presented in boldfaced type, is followed by brief clarifying remarks. The second column of the tables provide the number of drivers that gave a particular response. Because drivers could, and often did, provide multiple responses to each debriefing question, there were more responses than drivers providing responses. The third column of the tables provide a percentage that represents the frequency of a given response relative to all responses. The fourth column gives the percentage of drivers who gave that response. Note that “other” is sometimes a frequent category. This occurred when many idiosyncratic responses were given.

Rental users were debriefed at Orlando International Airport upon return of their TravTek vehicle to Avis Rental Car, Inc. The number of rental drivers for whom debriefing results are presented is somewhat less than the number of drivers debriefed (as reported in the Methods section) because a number of problems with the vehicle during the first month of operations resulted in comments

⁸ The Orlando Test Network Study, the and Yoked Driver Study participants were also debriefed using the same seven questions. ^(10,7)

that were not necessarily typical of comments received after the system “shake down.” The results reported here are from debriefings conducted after May 29, 1992. In the reporting period, debriefings were obtained from 394 Rental User drivers: 32 from the S configuration, 163 from the N configuration, and 199 from the N+ configuration. In presenting rental user debriefing findings, comments from the S configuration drivers are reported separately, because the system they drove, and the comments they made, were significantly different from renters from the other configurations. N+ and N configuration drivers tended to give similar responses and their debriefings are reported together. Comments specific to real-time traffic information, that is N+ drivers, are segregated at the bottom of the tables.

Local users were debriefed after they had driven their car for 1 week. Whereas it may seem odd to debrief users 1 week into an approximately 8-week experience, the debriefing was scheduled early for two reasons: (1) the debriefing would be comparable, in time, to the rental user debriefings — the average rental was about 1 week, and (2) the debriefing also served as an opportunity to explain any misunderstandings, or clarify system functions so that the local users would be more likely to fully test the system. Local users with the N+ and N configuration tended to give similar responses regardless of configuration. Therefore, local user debriefings, like those for renters, combine responses from N+ and N users.

Overall impressions. N+ and N configurations rental user responses are shown in table 54. Overall impressions of renters were generally favorable.

Table 54. N+ and N rental user responses to “Overall, what impressions do you have about TravTek now that you’ve had a chance to test drive the future?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Liked — stated they liked TravTek.	147	39.8%	40.6%
Strongly liked — stated they liked TravTek very much.	138	37.4%	38.1%
Awesome — TravTek described as fantastic, phenomenal, wonderful.	16	4.3%	4.4%
Fun — TravTek described as fun, enjoyable.	16	4.3%	4.4%
Fascinating — TravTek described as fascinating, interesting.	14	3.8%	3.9%
Within expectations — TravTek described as fine, okay.	12	3.3%	3.3%
Other — Catch all category for responses that were made by two or fewer drivers.	12	3.3%	3.3%
Problem with performance — stated they had a problem with the performance of the TravTek system (e.g., electrical problem, bugs in the system).	7	1.9%	1.9%
Disliked — stated they thought TravTek still needed a lot of development.	4	1.1%	1.1%
Good idea — TravTek described as a good idea, nice concept.	3	0.8%	0.8%

S configuration rental users’ most frequent responses are shown in table 55. Most of the comments were favorable, although many expressed a desire for a more usable map. It should be noted that because of TravTek publicity, a number of rental users who originally had S reservations requested and received one of the other configurations. The S debriefings represent responses from drivers who did not express strong dissatisfaction at the beginning of the rental period. Driver’s self selection out of the S configuration may have resulted in decreasing the number of drivers with negative impressions regarding the S condition in the debriefings.

Table 55. S rental user responses to “Overall, what impressions do you have about TravTek now that you’ve had a chance to test drive the future?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Liked — stated they liked TravTek.	10	31.3%	31.3%
Other — Catch all category for responses that were made by only one driver.	6	18.8%	18.8%
Did not use — stated they did not use the TravTek system.	5	15.6%	15.6%
Strongly liked — stated they liked TravTek very much.	3	9.4%	9.4%
Disliked — stated they disliked TravTek.	3	9.4%	9.4%
Maps not helpful — stated maps were useless if you were unfamiliar with the area.	3	9.4%	9.4%
Add navigational capabilities — stated TravTek was not very useful without Route Guidance capabilities.	2	6.3%	6.3%

Local users overall impressions of TravTek, shown in table 56, were almost unanimously favorable.

Table 56. Local users’ response to the question “Overall, what impressions do you have about TravTek now that you’ve had a chance to test drive the future?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Strongly liked — stated they liked TravTek very much.	24	47.1%	47.1%
Liked — stated they liked TravTek.	18	35.3%	35.3%
Other — Catch all category for responses that were made by only one driver.	4	7.8%	7.8%
Awesome — TravTek described as awesome, amazing, impressive.	2	3.9%	3.9%
Fascinating — TravTek described as fascinating, interesting.	2	3.9%	3.9%
No response — did not answer this question.	1	2.0%	2.0%

Favorite features. Table 56 presents a summary of responses to “What was your favorite feature” by rental users (N+ and N configurations). Among N+ and N configuration drivers, route guidance, or particular route guidance features, were most often mentioned as favorites. More than a few N and N+ drivers mentioned the Services and Attraction data base as their favorite feature.

Table 57 presents a summary of responses to “What was your favorite feature” for only the S configuration drivers. Not surprisingly, given that they had few alternatives, S configuration drivers most often mentioned the Services and Attraction data base as their favorite.

Table 57. N+ and N rental user responses to “What was your favorite feature?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Route guidance — liked the complete TravTek system, which included the Voice Guide, Guidance Display and the Route Map.	98	23.1%	27.1%
Voice guidance — liked aural turn-by-turn instructions. Some said that the voice enabled them to concentrate on driving without having to look at the screen.	74	17.4%	20.4%
Route Map — liked the detail the route map provided. Some said the route map allowed them to maintain their reference.	59	13.9%	16.3%
Guidance display — liked the turn-by-turn display. Some said that the guidance display was straightforward and provided clear instruction.	38	8.9%	10.5%
Services/Attraction — liked the information that was available through TravTek on area restaurants, hotels, and attractions. Some said they liked the ability to choose destination from the services/attraction menu.	29	6.8%	8.0%
Other — Catch all category for responses that were made by two or fewer drivers.	25	5.9%	6.9%
Map of local area — liked how the map of the local area tracked where you were even though route guidance was off.	22	5.2%	6.1%
Saved destinations — liked the time savings the saved destination feature provided for frequently made destinations.	13	3.1%	3.6%
OK NEW ROUTE — liked the OK NEW ROUTE function.	13	3.1%	3.6%
WHERE AM I — liked the WHERE AM I function. Some said they liked knowing that the car knew where they were.	13	3.1%	3.6%
SWAP MAP — liked how the SWAP MAP button enabled switching between the Guidance Display and Route Map.	12	2.8%	3.3%
None — declined to name favorite feature.	12	2.8%	3.3%
Planning destination — liked the ease of planning a route with TravTek.	4	0.9%	1.1%
Next turn warning — liked the advance warning of the next turn that TravTek provided.	4	0.9 %	1.1%
Avoid tolls — liked the ability to choose the routing option of avoiding toll roads.	3	0.7%	0.8%
No response — driver did not answer this question.	3	0.7%	0.8%
Traffic Information — liked the traffic information feature. Some said this feature provided travel time savings. ¹	3	1.3%	1.5%

¹Because only drivers in the N+ configuration had the traffic information feature, percentages for this response include only N+ drivers.

Table 58. S rental user responses to “What was your favorite feature?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Services/Attraction — liked the information that was available through TravTek on area restaurants, hotels, and attractions. Some said they liked how TravTek displayed where the service/attraction was located.	11	32.4%	34.4%
None — declined to name favorite feature.	5	14.7%	15.6%
Did not use — stated they did not use the TravTek system.	5	14.7%	15.6%
Cellular phone — liked the hands free cellular phone. Some said they liked the security the cellular phone provided.	4	11.8%	12.5%
Other — Catch all category for responses that were made by only one driver.	4	11.8%	12.5%
No response — did not answer this question.	3	8.8%	9.4%
Menus — liked the menu structure of the TravTek system.	2	5.9%	6.3%

Local users also cited route guidance features most often as favorites. Their responses are summarized in table 58. Interestingly, four local users mentioned SWAP MAP as a favorite feature. Rather than an exclusive preference for the Route Map or Guidance Display, these users preferred to use both. It is also important to note that many rental and local users specifically mention Voice Guidance as a favorite feature. Synthesized and digital voice systems have not always been well received in automobiles. However, the response to the TravTek implementation clearly shows that when properly implemented motorists appreciate electronic voice display functions.

Table 59. Local user responses to “What was your favorite feature?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Route Map — liked the detail the route map provided.	13	21.0%	25.5%
Route guidance — liked the complete TravTek system, which included the Voice Guide, Guidance Display and the Route Map.	12	19.4%	23.5%
Voice guidance — liked aural turn-by-turn instructions. Some said that the voice enabled them to concentrate on driving without having to look at the screen.	9	14.5%	17.6%
Other — Catch all category for responses that were made by only one driver.	9	14.5%	17.6%
Guidance display — liked the turn-by-turn display. Some said that the guidance display was straightforward and provided clear instruction.	5	8.1%	9.8%
SWAP MAP - liked how the SWAP MAP button enabled switching between the Guidance Display and Route Map.	4	6.5%	7.8%
Map of local area — liked to use the map of the local area to determine where streets went.	3	4.8%	5.9%
Services/Attraction — liked the Services information that was available through TravTek for such things as locating ATM's and restaurants.	3	4.8%	5.9%
WHERE AM I — liked the WHERE AM I function.	2	3.2%	3.9%
Cellular phone - liked the hands free cellular phone.	2	3.2%	3.9%

Least Favorite Features. Responses to the question “What was your least favorite feature” are summarized in table 59 for the N+ and N configuration drivers in the Rental User Study. Among N+ and N renters, the quality of the synthesized voice was the most frequently cited least favorite feature. These comments were directed not at the desirability of having a voice supplement to the visual display, but specifically to the quality of the voice. It was not uncommon for the same users who cited the Voice Guide as a favorite feature, to cite voice quality as a least favorite feature. Many users thought that the voice sounded foreign, a comment that was as common among non-native English speakers as it was among native speakers. Whereas many users requested a better sounding voice system, few suggested that they would prefer not to have the voice unless its sound was improved. Rental users also frequently mentioned, as a least favorite feature, the keyboard interface for input of a destination.

Among S configuration users, idiosyncratic comments were the most frequent response to the question “What was your least favorite feature?” Their responses are summarized in table 60. Four users specifically mentioned that they desired the navigation map function.

Table 60. N+ and N rental user responses to “What was your least favorite feature?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Voice quality — the sound or intelligibility of the Voice Guide.	77	19.9%	21.3%
None — declined to name least favorite feature.	60	15.5%	16.6%
Other — Catch all category for responses that were made by three or fewer drivers.	58	15.0%	16.0%
Keyboard interface — reported the touch screen keyboard awkward.	31	8.0%	8.6%
Incomplete Services/Attraction data base — the Services/Attraction directory did not include all hotels, post offices, convention centers.	22	5.7%	6.1%
Inability to zoom in or out while moving — the inability to change the scale of the Route Map while moving.	20	5.2%	5.5%
Having to be in park to program — did not like the requirement to be in PARK for destination entry.	18	4.7%	5.0%
Boot-up time — reported the time required for the TravTek system to start or to plan a route was too long.	17	4.4%	4.7%
Destination entry — did not like the time required to input a destination into the TravTek system.	16	4.1%	4.4%
Tracking problem — TravTek sometimes misrepresent the vehicle’s position and caused incorrect off route messages.	15	3.9%	4.1%
No response — driver did not answer this question.	9	2.3%	2.5%
Starting route — felt that TravTek did not give sufficiently explicit directions for beginning a route.	6	1.6%	1.7%
Drive limitations — did not like the inability to use all of the TravTek features while driving.	6	1.6%	1.7%
TravTek malfunction — reported a TravTek feature did not function correctly.	5	1.3%	1.4%
Phone features — reported phone was difficult to use and sometimes distracting.	5	1.3%	1.4%
Menu system — reported difficulty traversing through the menu structure.	5	1.3%	1.4%
Routed incorrectly — reported TravTek routed incorrectly to a given destination.	4	1.0%	1.1%
System can be distracting — reported difficulty looking at the visual display while driving.	4	1.0%	1.1%
Did not use — stated did not use the TravTek system.	1	0.3%	0.3%
Traffic information — traffic information was not accurate or up to date. ¹	8	3.8%	4.0%

¹Because only drivers in the N+ configuration had the traffic information feature, percentages for this response were calculated only from the N+ sample.

Table 6 1. S rental user responses to “What was your least favorite feature?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Other — Catch all category for responses that were made by only one driver.	9	27.3%	28.1%
None — declined to name least favorite feature.	7	21.2%	21.9%
Did not use — stated they did not use the TravTek system.	5	15.2%	15.6%
Inability to use map while driving — the inability to use the map while driving.	4	12.1%	12.5%
No response — did not answer this question.	3	9.1%	9.4%
Map — not enough detail on map.	3	9.1%	9.4%
Key response time — slow response time after pressing a move map key.	2	6.1%	6.3%

Among local users, voice quality was also an issue. Their responses are summarized in table 61. Unique to local drivers was the objection to the interruption of radio programs by voice messages. Local users also did not like receiving traffic alert messages for areas that, in their perception, were well away from their route of travel. When there is no planned route, filtering traffic information to present only that which is relevant to the user is difficult, and TravTek provided information over a wide area. This sometimes resulted in traffic messages that were quite lengthy. When a planned route was installed, only information relevant to that route was presented, and users infrequently complained about those messages.

Table 62. Local user responses to “What was your least favorite feature?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Other — Catch all category for responses that were made by only one driver.	16	28.6%	31.4%
Destination entry — the time required to input a destination into the TravTek system. Some said the TravTek system sometimes did not recognize a particular street name.	7	12.5%	13.7%
Voice quality — did not like the sound or intelligibility of the Voice Guide.	6	10.7%	11.8%
Boot-up time — reported the time required for the TravTek system to start or to plan a route was too long.	6	10.7%	11.8%
Keyboard interface — reported the touch screen keyboard awkward or too sensitive.	5	8.9%	9.8%
Tracking problem -TravTek sometimes misrepresented the vehicle’s position and caused incorrect off-route messages.	3	5.4%	5.9%
Voice interruptions -voice would interrupted radio programs.	3	5.4%	5.9%
Phone features — reported trouble getting phone to work.	3	5.4%	5.9%
Services/Attraction malfunction — reported that this feature did not function correctly when make destination was selected the Services/Attraction screen.	2	3.6%	3.9%
Inability to zoom in or out while moving — the map scale could not be changed while moving.	2	3.6%	3.9%
None — declined to name least favorite feature.	1	1.8%	2.0%
Traffic report — the traffic reports for areas not in the vicinity of the route. ¹	2	6.9%	7.7%

¹Because only drivers in the N+ configuration had the traffic report feature, percentages for this response was calculated using only the N+ sample in the denominator.

When TravTek was Especially Helpful. Renters with the N+ and N either volunteered an instance when TravTek was especially helpful (most often in finding destinations) or declined to name a specific instance because they found TravTek to be generally helpful. A summary of N+ and N driver responses to the “especially helpful” question is shown in table 63.

In contrast to N and N+ configuration renters, S configuration renters often did not perceive situations in which the system was especially helpful. A summary of S configuration drivers’ responses to this question is shown in table 64.

Table 63. N+ and N rental user responses to “Were there any situations where TravTek was especially helpful?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Finding specific destination — TravTek was helpful locating a particular destination especially when in an unfamiliar area.	136	36.0%	37.6%
None — in no instance was TravTek especially helpful.	55	14.6%	15.2%
Other- Catch all category for responses that were made by two or fewer drivers.	33	8.7%	9.1%
TravTek was generally helpful — driver declined to name a specific instance where TravTek was especially helpful but said that TravTek was generally helpful.	25	6.6%	6.9%
Off-route message and OK NEW ROUTE feature — the off-route message and OK NEW ROUTE? feature got them back onto a planned route.	20	5.3%	5.5%
Route guidance — the Voice Guide, Guidance Display, and Route Map.	18	4.8%	5.0%
TravTek was helpful all the time — driver declined to name a specific instance where TravTek was especially helpful. Stated that TravTek was always very helpful.	16	4.2%	4.4%
TravTek was reliable — driver declined to name a specific instance where TravTek was especially helpful. Stated that TravTek functioned correctly most of the time.	15	4.0%	4.1%
No response — driver did not answer this question.	14	3.7%	3.9%
Night-time operation — TravTek was helpful with night-time driving	10	2.6%	2.8%
Services/Attraction directory information — used the information that was available through TravTek to select restaurants, attractions, and services.	9	2.4%	2.5%
Map when out of coverage area — used map of local area to navigate by, when out of TravTek coverage area.	7	1.9%	1.9%
Saved time — the time savings TravTek provided.	5	1.3%	1.4%
Distance to next maneuver — the advanced warning TravTek provided for the next turn.	4	1.1%	1.1%
Route map — the detail the Route Map provided was helpful. Some said the Route Map allowed them to maintain their reference.	3	0.8%	0.8%
Did not use — stated did not use the TravTek system.	1	0.3%	0.3%
Traffic information — ability to avoid traffic congestion. ¹	7	3.3%	3.5%

¹Because only drivers in the N+ configuration had the traffic report feature, percentages for this response was calculated using only the N+ sample in the denominator.

Table 64. Renters with the S responses to “Were there any situations where TravTek was especially helpful?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
None — there was no instance where TravTek was especially helpful.	13	39.4%	40.6%
Did not use — stated they did not use the TravTek system.	5	15.2%	15.6%
No response — did not answer this question.	4	12.1%	12.5%
Finding specific destination — TravTek was helpful locating a particular destination.	3	9.1%	9.4%
Services/Attractions directory information — used the information that was available through TravTek to select a restaurant.	3	9.1%	9.4%
Other — Catch all category for responses that were made by only one driver.	3	9.1%	9.4%
Cellular phone — used the cellular phone to call and ask for directions.	2	6.1%	6.3%

Local user responses to the “especially helpful” question are summarized in table 65. As with renters with navigation functions, locals most often mentioned route guidance as especially helpful.

Table 65. Local users responses to “Were there any situations where TravTek was especially helpful?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Finding specific destination — TravTek was helpful locating a particular destination especially when in an unfamiliar area.	32	60.4%	62.7%
Other- Catch all category for responses that were made by only one driver.	7	13.2%	13.7%
Distance to next maneuver — the advanced warning TravTek provided for the next turn.	3	5.7%	5.9%
Route guidance — the Voice Guide, Guidance Display, and Route Map.	3	5.7%	5.9%
None — in no instance was TravTek especially helpful.	3	5.7%	5.9%
TravTek provided shortcuts — In some instances TravTek knew a short cut that driver was not aware existed.	3	5.7%	5.9%
Route Map — the detail the Route Map provided was helpful.	2	3.8%	3.9%

When TravTek Did Not Help. Table 66 summarizes N+ and N configuration rental drivers responses to the question “Were there any situations where TravTek was not helpful?” Their most frequent response to this question was that TravTek sometimes suggested unusual, illegal, or impossible maneuvers. Some examples of this were: showing through or connecting streets that did not intersect; suggesting two left turns rather than a U-turn on divided highways; suggesting U-turns at locations where posted signs prohibited that maneuver. As the overall responses suggest, such instances were rare, but they were not helpful when they did occur. Most of the problems could be addressed with improvements to the map data base. Others, such as describing a U-turn on a divided highway as two left turns, could be corrected with minor changes to the route guidance software.

A summary of S configuration rental drivers’ responses to the question “While driving with TravTek, were there any situations where TravTek was not helpful?” is provided in table 67. The finding that the most frequent response was that there were no specific instances when TravTek was not helpful should be viewed in the context that in general, the system was not viewed as helpful by these drivers.

Table 66. N+ and N configuration rental drivers' responses to "Were there any situations where TravTek was not helpful?"

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Weird routing — sometimes TravTek suggested a maneuver that was not intuitive, legal, or possible.	96	24.7%	26.5%
None — there was no instance where TravTek was not helpful.	77	19.8%	21.3%
Tracking problems — it was confusing when TravTek incorrectly displayed the car's current location.	67	17.3%	18.5%
Other — Catch all category for responses that were made by two or fewer drivers.	42	10.8%	11.6%
Services/Attraction data base — instances where a service/attraction was not located in the services/attraction data base.	30	7.7%	8.3%
Problems with voice — on occasion the voice did not function.	17	4.4%	4.7%
No response — driver did not answer this question.	8	2.1%	2.2%
Using TravTek in parking lots — initial instructions from TravTek were unclear as to how to exit parking lots.	8	2.1%	2.2%
System can be distracting — the system could be distracting under certain conditions.	6	1.5%	1.7%
TravTek not specific enough when reaching destination — upon nearing the planned destination, TravTek announced that 'you are in the vicinity of your destination.' At that point, route guidance ended.	6	1.5%	1.7%
Data base errors — TravTek displayed a section of roadway incorrectly.	6	1.5%	1.7%
Inability to program while driving — the requirement to be in park to program a destination.	5	1.3%	1.4%
Limited coverage area — TravTek did not include coverage for all areas.	4	1.0%	1.1%
Data base not comprehensive — TravTek did not recognize some street names when attempting to enter a destination,	4	1.0%	1.1%
Street names not consistent with street signs — conflicts between street signs and street names used by TravTek.	3	0.8%	0.8%
Had to exchange car — had to exchange car due to a TravTek malfunction.	3	0.8%	0.8%
Did not use — stated did not use the TravTek system.	1	0.3%	0.3%
Traffic information — traffic information was not reliable. ¹	5	2.4%	2.5%

¹Because only drivers in the N+ configuration had the traffic report feature, percentages for this response was calculated using only the N+ sample in the denominator.

Table 67. S configuration rental drivers' responses to "Were there any situations where TravTek was not helpful?"

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
None — there was no instance where TravTek was not helpful.	13	40.6%	40.6%
Other — Catch all category for responses that were made by only one driver.	12	37.5%	37.5%
Did not use — stated they did not use the TravTek system.	5	15.6%	15.6%
No response — did not answer this question.	2	6.3%	6.3%

Local user responses to the "not helpful" question, summarized in table 68, were similar to those of renters. In addition to noting unusual routing instructions, as did the renters, locals also commented that TravTek sometimes did not select the fastest or most direct route. TravTek avoided

short-cuts through residential areas, school zones, and fire stations. It also had a preference for higher classification roadways. Thus it is not surprising that the local users' greater knowledge of available routes, compared to the rental visitor, led them to perceive routings that appeared non-optimal because of the system's routing restrictions. Although users could preview TravTek's planned routes, there was no provision for the user to override routing choices made by the system. Users could deviate from the planned route and press OK NEW ROUTE when the system detected the deviation. Even this work around was not totally adequate, as the system sometimes simply recommended a U-turn to return to its original plan.

Table 68. Local users' responses to "Were there any situations where TravTek was not helpful?"

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Weird routing — sometimes TravTek suggested a maneuver that was not intuitive, legal, or possible Some said occasionally TravTek suggested routes that were not the fastest or the most direct.	20	35.7%	39.2%
Other — Catch all category for responses that were made by only one driver.	17	30.4%	33.3%
Tracking problems — it was confusing when TravTek incorrectly displayed the car's current location.	8	14.3%	15.7%
None — there was no instance where TravTek was not helpful.	3	5.4%	5.9%
Locating a Services/Attraction in the data base — was time consuming to locate a particular service or attraction in the Services/Attraction data base.	3	5.4%	5.9%
Problems with voice — the synthesized voice system did not always function properly.	2	3.6%	3.9%
Traffic information — traffic information was not current. ¹	3	10.0%	11.5%

¹Because only drivers in the N+ configuration had the traffic report feature, percentages for this response was calculated using only the N+ sample in the denominator.

TravTek Training. Prior to arriving in Orlando, renters who made reservations through AAA received brochures and a video that described use of the TravTek system. Rental users who did not make reservations through AAA, or made reservations at the last minute generally did not see the video or brochures. Local users were provided with the same brochures and video. Upon arrival in Orlando, most renters were given a brief in-vehicle introduction to the TravTek system. When they first received their TravTek vehicle, local users were given an extensive briefing and a 5 min test drive.

In the debriefing, users were asked "Did the brochure, video, and orientation you were given prepare you for driving with TravTek?" The responses to this question may provide an additional indication of ease of learning of the TravTek system, as well as the extensiveness of training required for use of in-vehicle systems such as TravTek.

Although the majority of N+ and N renters thought the training was adequate, a substantial number desired more hands on training. Many of the functions for which these drivers wanted more training were only available when the vehicle was on a planned route — hands on training for these was not possible in the airport parking garage. N+ and N user responses are summarized in table 69.

Table 69. N+ and N rental users' responses to the question "Did the brochure, video, and orientation you were given prepare you for driving with TravTek?"

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Everything was fine -brochure, video, and orientation were all helpful.	184	42.7%	50.8%
Training was good — training was helpful.	79	18.3%	21.8%
Video was good — video was helpful.	54	12.5%	14.9%
Training was not good — training was not helpful. Some said it would have been better to do the programming themselves rather than observing the instructor perform this.	34	7.9%	9.4%
Brochure was good — brochure was helpful.	27	6.3%	7.5%
Training was too brief — received training but would have liked more training on specific features (e.g., phone, hop left/hop right, SWAP MAP).	23	5.3%	6.4%
Didn't receive brochure/video — did not receive a video or a brochure.	9	2.1%	2.5%
Other — Catch all category for responses that were made by two or fewer drivers.	8	1.9%	2.2%
No response — driver did not answer this question.	7	1.6%	1.9%
Didn't receive orientation — did not receive an orientation.	6	1.4%	1.7%

The responses of S configuration renters, summarized in table 70, suggested that even for the limited functions provided that group, some people would desire more hands on training.

Table 70. S rental users' responses to the question "Did the brochure, video, and orientation you were given prepare you for driving with TravTek?"

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Everything was fine — brochure, video, and orientation were all helpful.	11	31.4%	34.4%
Training was too brief — received training but would have liked more.	5	14.3%	15.6%
Training was good training was helpful.	5	14.3%	15.6%
Training was not good — received either very little training or no training at all.	5	14.3%	15.6%
No response — did not answer this question.	5	14.3%	15.6%
Video was good — video was helpful.	2	5.7%	6.3%
Brochure was good -brochure was helpful.	2	5.7%	6.3%

Local users, most of whom received on road training, generally found the training to be adequate. Local user responses are summarized in table 7 1. Even so, two users commented that the system was difficult to learn.

Table 71. Local user responses to the question “Did the brochure, video, and orientation you were given prepare you for driving with TravTek?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers -</i>
Everything was fine — brochure, video, and orientation were all helpful.	37	68.5%	72.5%
Training was good — training was helpful.	5	9.3%	9.8%
Other — Catch all category for responses that were made by only one driver.	5	9.3%	9.8%
No response — driver did not answer this question.	3	5.6%	5.9%
Video was good — video was helpful	2	3.7%	3.9%
Overwhelming — TravTek system was overwhelming at first.	2	3.7%	3.9%

In summary, most users found the training they received to be adequate. A minority may have benefited from an introductory drive.

Suggestions for Improvement. The final question asked during the debriefing was “Can you think of anything that could be improved about TravTek to make it better?” Responses to this debrief question are summarized in table 71 for N+ and N configuration drivers.

N+ and N configuration users frequently mentioned the synthesized voice as an area that could benefit from improvement. Another frequently requested improvement was for easier input of text into the system. An example of the touch keypad, as it was presented on the TravTek video display, is shown in figure 20. Four letters or numbers were displayed on each of nine keys. Entering a letter or number was a two step process. First, the key that included the target letter plus three others was pressed. This caused presentation of four additional keys at the bottom of the display. Second, the desired number or letter was selected from the bottom row. It was generally only necessary to enter the first four letters of a street name before pressing DONE. Pressing DONE would bring up a list of streets beginning with those letters. The touch keypad arrangement enabled entry of streets without the requirement for a dedicated keyboard. Whereas the touch keypad obviated the need for a dedicated keyboard, and although it is difficult to imagine a less awkward implementation given a 127~mm video display, more than a few users expressed a desire for an input system that is easier to use. Many of the numerous other suggestions that were offered are summarized in the table.

Table 72. N+ and N renters' responses to "Can you think of anything that could be improved about TravTek to make it better"

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Other — Catch all category for responses that were made by three or fewer drivers.	104	21.0%	28.7%
Improve voice — improve clarity of the voice.	46	9.3%	12.7%
Improve keyboard interface — the user-friendliness of the keyboard interface needs improvement.	42	8.5%	11.6%
Improve Services/Attractions data base — the user-friendliness of the Services/Attractions menu structure needed improvement.	40	8.1%	11.0%
Ability to Zoom in/Zoom out while driving — the capability to change the scale on the Route Map while moving.	34	6.9%	9.4%
None — nothing needs to be improved.	31	6.3%	8.6%
Programming ability while driving — the ability to program a destination while driving.	28	5.7%	7.7%
Shorten boot-up time — shorten the time required for the TravTek system to boot-up.	18	3.6%	5.0%
Heads-up display — the display needs to be positioned so that drivers can keep their head up while driving.	17	3.4%	4.7%
Include route preview — the ability to view the entire route before beginning to drive.	16	3.2%	4.4%
Improve tracking — the computation of present position needs improvement.	13	2.6%	3.6%
Eliminate park restriction if passenger in car — permit passenger to enter destinations while under way.	13	2.6%	3.6%
Screen size — a larger visual display is needed.	11	2.2%	3.0%
Expand coverage area -would like more area covered.	11	2.2%	3.0%
Eliminate drive limitations — want to use all features while driving.	10	2.0%	2.8%
Cancel destination while driving — want to cancel a destination while driving.	9	1.8%	2.5%
No response — did not answer this question.	9	1.8%	2.5%
Toll booth location — display toll booth locations.	9	1.8%	2.5%
Compass — the ability to view a compass at all times	8	1.6%	2.2%
More advanced warning of next turn — increase distance before announcement of direction of next turn.	7	1.4%	1.9%
Improve data base — would like the street names to match the corresponding street signs	6	1.2%	1.7%
Access to help -Some suggested help key on drive screens.	4	0.8%	1.1%
Canceling destination — make canceling destination easier. Some suggested providing a cancel destination key.	4	0.8%	1.1%
Menu structure — make menu structure easier to use.	4	0.8%	1.1%
Did not use — stated did not use the TravTek system.	1	0.2%	0.3%

S configuration user responses are summarized in table 72. The majority of these responses reflected a desire for functions that were available in the other two vehicle configurations.

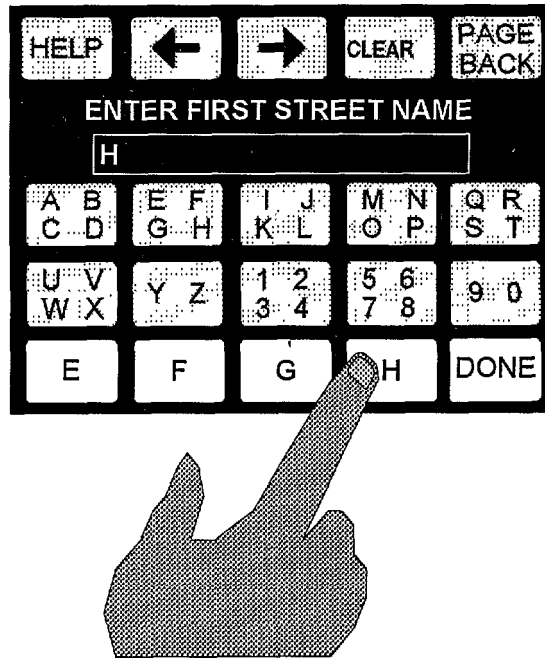


Figure 20. An example of the TravTek “keyboard” interface.

Table 73. Renters with the S configuration responses to the question “Can you think of anything that could be improved about TravTek to make it better?”

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Other — Catch all category for responses that were made by only one driver.	9	23.1%	28.1%
Add navigational capabilities — would like route guidance capabilities to be added.	8	20.5%	25.0%
Did not use — stated they did not use the TravTek system.	5	12.8%	15.6%
Expand coverage area — the area covered by TravTek needs to be expanded.	4	10.3%	12.5%
Indicate car location — would like the map to indicate the current location of the car.	3	7.7%	9.4%
Improve keyboard interface — the user-friendliness of the keyboard interface needs improvement.	2	5.1%	6.3%
Improve Services/Attraction data base — provide more information about attractions; include information on restaurant reviews, movie reviews, and a calendar of events.	2	5.1%	6.3%
Screen size — a larger visual display is needed.	2	5.1%	6.3%
No response — did not answer this question.	2	5.1%	6.3%

Local user suggestions for improvements, shown in table 74, were similar to those given by rental users who had the N and N+ configurations.

Table 74. Local user responses to the question "Can you think of anything that could be improved about TravTek to make it better?"

<i>Response</i>	<i>Frequency</i>	<i>Percent of Responses</i>	<i>Percent of Drivers</i>
Other — Catch all category for responses that were made by only one driver.	25	43.1%	49.0%
Improve keyboard interface — the user-friendliness of the keyboard interface needs improvement. Some said the process was too time consuming.	8	13.8%	15.7%
Shorten boot-up time — shorten the time required for the TravTek system to boot-up and the time required for TravTek to plan a route.	6	10.3%	11.8%
Improve data base — would like the street names TravTek uses to match the corresponding street signs.	6	10.3%	11.8%
Include route preview — the ability to view the entire route before beginning to drive.	3	5.2%	5.9%
Improve voice — the clarity of the voice guidance needed improvement.	2	3.4%	3.9%
None — nothing needs to be improved.	2	3.4%	3.9%
Improve Services/Attractions data base — the user-friendliness of the Services/Attractions menu structure needs improvement.	2	3.4%	3.9%
Screen size — a larger visual display is needed.	2	3.4%	3.9%
Improve non-TravTek features — suggestions for improvements not related to TravTek (e.g., cup holders).	2	3.4%	3.9%

DISCUSSION

The Rental User Study and Local User Study each made significant contributions to our understanding of how users perceive and use ATIS in-vehicle systems in general, and the TravTek system in particular. The discussion that follows summarizes those contributions with the respect to the four issues defined in the Introduction.

Does TravTek Affect Driver Performance, Behavior, and Satisfaction?

In assessing driver performance behavior and satisfaction with the TravTek system three general topic areas were examined:

1. Drivers' perceptions of the effects of the TravTek system on their driving and navigation performance.
2. The extent of usage of TravTek features and functions
3. Drivers' expressed satisfaction with TravTek features and functions,

Questionnaire responses were examined to determine TravTek user perceptions of the effects of TravTek on way-finding, travel time, trip generation, safety, and driver workload. Respondents indicated effects on all five areas of performance. In general, perceptions were favorable.

Way-finding. Both rental and local users who experienced the route planning and route guidance aspects of the TravTek system strongly agreed with the assertion that the TravTek system "Helped me find my way." Renters, most of whom were visitors to the Orlando area, reported the system was helpful in way-finding, suggesting that the system worked fairly well. More importantly, Orlando area residents, who were selected for participation because they drive a lot within the coverage area, also reported the system helpful in way-finding. The finding that route planning and route guidance is useful for everyday driving in users' home area suggests that navigation and route guidance systems such as TravTek may have a market well beyond the tourist, rental car and frequent traveler markets. This suggestion is reinforced by the finding that local users' estimates of what they would pay for TravTek as an option on a new car were about the same as those for visitors. About half of all respondents, locals and visitors, judged that TravTek would be useful for driving close to home.

Travel Time. Renters who experienced either the N+ or N configurations generally agreed with the assertion that TravTek helped them save time. Local users, also agreed with that assertion and to about the same degree. Renters who experienced the S configuration indicated that TravTek did not save them time. Because those with navigation functions reported that TravTek saved time, whereas those without navigation functions did not report a time savings, it is likely that the navigation functions (navigation, route planning, and route guidance) were perceived as the source of the time saving. In another TravTek study, the Yoked Driver Study, large time savings due to trip planning function were found — 2 min with TravTek versus 10 min without — in planning a 16.2-km trip between two residential addresses. For those same trips, a modest travel time saving of 2 min was observed favoring vehicles in the N+ and N configurations over a control (S) configuration. No additional time saving was attributable to real-time travel information (i.e., no travel time difference between N+ and N). From the questionnaire responses, it cannot be

determined which TravTek functions were perceived as the source of the time savings. However the Yoked Driver Study findings suggest it would be reasonable to attribute savings to the trip planning and route guidance functions.

The finding that users perceived a time savings is important because it supports the notion that if such systems are fielded, they will be used by drivers who wish to save time. If ATIS systems are to achieve their social goals, e.g., reduced congestion, increased traffic flow, they must be used, and this finding, along with others from these studies, suggests that the systems will be used.

Trip Generation. Roughly one-third of N+ and N renters said that TravTek influenced the number or length of trips they took. Among the one-third who said that TravTek influenced the length or number of trips, 98 percent said that they took longer trips because of TravTek whereas only 30 percent said they took shorter trips (the same drivers could have been influenced to take some longer and some shorter trips). Among the roughly one-third of respondents that said they changed travel plans because of information provided by TravTek, the majority said that they changed destinations. Those with real-time traffic information were the most likely to change destinations.

It appears that TravTek-like systems will change travel behavior. Respondents indicated a willingness to change destinations based on travel information provided by TravTek, and this could be a benefit to traffic managers who may wish to use ATIS systems to divert travelers from congested roadways. However, some users also indicated that they were influenced by TravTek to take longer trips. If this effect were widespread, increased travel demand might negate benefits accrued from improved traffic management. About two-thirds of TravTek renters indicated that TravTek did not cause them to alter travel plans, and among those who said they changed plans, some said they took shorter trips or canceled trips. Therefore, while the findings suggest that TravTek-like systems may generate more or longer trips, they do not suggest that the magnitude of that effect will be large. Furthermore, the *TravTek Evaluation Modeling Study* findings suggest that TravTek benefits in reduced congestion might well offset any negative effects of increased trip generation. ⁽⁸⁾

Safety. Both renters and local users tended to agree that TravTek helped them drive more safely. The number of renters who reported experiencing close calls was proportionally equivalent among TravTek N+, N and S (control) drivers. Slightly less than half the TravTek users who perceived close calls said they had been looking at a TravTek display, or otherwise interacting with TravTek just prior to a close call. Drivers who reported interacting with TravTek just prior to a close call tended to blame themselves for the close call. However, these data should not be assumed to implicate TravTek as a cause of close calls because respondents operating non-TravTek in-vehicle devices also tended to blame themselves, and the S group — that did not have TravTek to distract them — were equally likely to report perceived close calls. Furthermore, there were no TravTek related accidents among either TravTek rental users or local users during the entire operational test. ⁽¹¹⁾

Interference with, and Attention to, Driving. The effects of the TravTek system on perceived driver workload were assessed by examining responses to assertions that the TravTek system and its functions “Interfered with my driving” and “Helped me pay more attention to my driving.” Both

renters and local users who had either N+ or N configurations disagreed with assertions that TravTek interfered with their driving. Users agreed that TravTek helped them be more attentive to their driving. Furthermore respondents indicated that TravTek made them feel more confident, attentive and safe, and less nervous and confused. Even drivers that claim to have experienced close calls while interacting with the TravTek system did not, on average, suggest that TravTek interfered with their driving.

The rental and local user study findings, taken as a whole, suggest that users strongly felt that the TravTek route guidance features contributed to safer, more relaxed, driving experiences. These findings are consistent with findings from three other TravTek studies (the Yoked Driver Study, Orlando Test Network Study, and Camera Car Study) in which drivers were asked at various points during trips to rate their perceived workload.^(6,7,10)

Stated Preference for Display Formats. Rental users, who were primarily visitors, most preferred the TravTek visual displays supplemented by the Voice Guide. That is, renters liked the Route Map and Guidance Display about equally well when those displays were supplemented by the Voice Guide. Renters were almost neutral (neither liked nor disliked) the two visual display formats when those displays were not supplemented by the Voice Guide. These findings strongly support the use of a carefully human factored voice supplement to ATIS in-vehicle displays.

Local users, who were familiar with the Orlando area, and used the TravTek vehicles in their routine daily activities, most liked the Route Map without voice supplement. However, local users liked all the displays — their preference for Route Map without Voice Guide was relative. With respect to using the Voice Guide without visual display, local users were neutral, expressing neither strong like nor dislike.

Actual Display Usage. Actual use of TravTek displays was automatically recorded in the vehicles. N+ and N renters used TravTek to plan 55 percent of their trips. Local users, who had the vehicles for 2 months, also used the TravTek system to plan routes for about half of all their trips. On trips for which they used TravTek to plan their route, renters used the TravTek default display configuration, the turn-by-turn Guidance Display supplemented by the Voice Guide, about 70 percent of the time. Renters had the Voice Guide on roughly 85 percent of the time, and used the Route Map about 15 percent of the time. That renters kept the Voice Guide on most of the time further highlights their stated preference of the Voice Guide. The Voice Guide could easily be turned off by pressing a clearly marked button on the steering wheel hub; the high observed usage of the Voice Guide cannot easily be attributed to the fact that the system defaulted to Voice Guide on.

Despite giving the highest “liked” rating to the Route Map without Voice Guide, locals used the Guidance Display 63 percent of the time and the Guidance Display with Voice Guide (the system default) 43 percent of the time. They used their most liked display combination only 17 percent of the time. Because of the stated preference of local users to drive without the Voice Guide, and to use the Route Map, designers should consider retaining the two display formats and voice guidance as an option on future ATIS systems.

Use of Other Functions. Use of three other TravTek functions that were available while driving were examined: (1) acceptance of better routes, (2) use of TRAFFIC REPORT, and (3) use of WHERE AM I.

Better routes were offered only on rare occasions. To be offered a better route: (1) the user had to be in the N+ configuration, (2) a significant change in travel time had to be detected by the TravTek system after the trip began, and (3) an alternate route had to be available that was significantly faster than the route the TravTek system had originally planned. Among the renters included in our analyses, better routes were offered on only 21 trips out of a possible 17,667 trips. In all but four instances that better routes were offered, the rental driver accepted the better route. In at least one of the four instances there is evidence that the driver tried to accept a better route but pushed the wrong button.

Local users were offered better routes on 15 trips out of a possible 5,588 trips. Local users accepted the better route on 8 of the 15 occasions. On all occasions that local users accepted better routes, the Voice Guide was on. On those eight occasions it can be assumed that the local users knew a better route was being offered. On six of the seven occasions that local users did not accept better routes, the Voice Guide was turned off. A strong implication of this finding is that a distinctive aural alert is necessary if drivers are to be made aware of time critical traffic information. The system did have a aural chime that alerted drivers to changes in the TravTek display when the Voice Guide was off.⁽⁴⁾ The available evidence suggests either that this chime was not compelling enough, or that training in the meaning of TravTek chimes is needed. None of the TravTek training materials discussed the chimes.

The video display of the better route available message appeared as a large white banner that would have been noticed if the users had looked at the display. However, whereas the in-vehicle log data indicate whether the Guidance Display or Route Map was selected, they do not indicate whether the TravTek display was visible: Radio, climate control, and vehicle systems displays could have been selected without an indication in the in-vehicle log that the driver had changed displays. Therefore we cannot say whether local users who turned the Voice Guide off did not accept better routes because (1) they did not look at the TravTek display, (2) they did not have a TravTek visual display selected, or (3) they saw the better route message but did not wish to accept it. In any case, all local drivers who had the Voice Guide on accepted the better route and this implies that aural voice messages are effective in eliciting acceptance of new routes.

The TRAFFIC REPORT button on the steering wheel hub toggled synthesized voice reports of traffic information on and off. The default was off. When on a planned route, only traffic reports relevant to the planned route were delivered. When no route was planned, or the vehicle was off the planned route, all traffic reports for a wide area of the network were delivered. The TRAFFIC REPORT feature was exclusive to the N+ configuration.

Most renters and local users used the TRAFFIC REPORT feature at least once. Overall, N+ renters had traffic report on 14 percent of the time when a planned route was installed, and 11 percent of the time otherwise. Overall, local users drove with traffic report turned on about 7 percent of the time. Renters rated the utility of the traffic report feature at 4.2 on a six point scale where 3.5

would be neutral (neither useful or not useful) and six indicated strong agreement that the feature was useful.

Use of the TRAFFIC REPORT feature may have been reduced due to the perceived quality of the traffic information provided. The *TravTek System Architecture Evaluation* documented problems with the quality of TravTek traffic information.(9)

When pressed, the WHERE AM I button on the steering wheel hub caused the system to deliver a synthesized voice message announcing the current street, heading, and next cross street. This function was not used frequently. Renters pressed the WHERE AM I button an average of 1.16 times per trip, although 91 percent used the function at least once. Local users used the WHERE AM I function about once every five trips. However, frequency of use may not be a good metric for the utility of this function. Local users, who used WHERE AM I less than renters, nonetheless provided questionnaire ratings that suggest they found the function useful. Local user ratings of the utility of this function, were high and not significantly different from renter ratings.

Learnability and Usability. TravTek users were asked a number of questions concerning the ease of learning and ease of use of the TravTek system. Both renters and local users gave the system high ratings for learnability and usability, and local users rated the system slightly higher than renters. Debriefing comments suggest that hands on training, especially on the road training, would be useful to some drivers.

Features Available While in PARK. Frequency of use, and usability of three TravTek features available only when the vehicle was in PARK were examined: the help system, the help desk, and the screen for selecting alternative route planning criteria.

Help Function. Three fourths of the renters used the help feature more than once, and about 40 percent used it more than five times. On average, renters accessed help on about one out of every four trips. Local users made even more use of the help system, especially during the first month of their TravTek experience. The help system received relatively high ratings for ease of use, and somewhat lower, but still favorable, ratings for usefulness. The findings suggest that, if a help function is included as part of a relatively sophisticated ATIS system, it will be used.

Help Desk. The TravTek help desk was available 24 h a day every day during the TravTek operational test. Yet most rental and local users never called the help desk. Only about 30 percent of rental users called the help desk through the TravTek system. Although the help desk also maintained a log of calls, that log was incomplete. However, the available data do not suggest that many more drivers called the help desk by means other than the TravTek system. Among local users, calls to the help desk were less frequent than among renters, only 17 percent of local drivers ever called the help desk.

Among those who did call the help desk, impressions were favorable. Help desk users gave very favorable ratings to the help desk for availability, usefulness, and accuracy.

Whereas these findings suggest that demand for a help desk function is low, it should be noted that the help desk operators called TravTek renters midway through each rental period, and this call may have reduced the need to call the help desk.

Routing Method. The TravTek system offered three routing criteria: fastest, avoid Interstates, and avoid toll roads. Renters chose fastest 87.9 percent of the time and avoid toll roads almost 8.5 percent of the time. Local users chose fastest slightly less frequently than renters, 76.3 percent of the time, but chose to avoid Interstates substantially more often, 15.6 percent of the time. Although both renters and local users selected fastest most of the time, users from both groups gave favorable ratings to the routing choice screen. Because the routing choice screen added a step to the route planning process, if users did not appreciate the opportunity to select routing criteria they would have been expected to give the screen a less favorable rating. The routing method choice appears to have been well received.

How Much are Drivers Willing to Pay for TravTek Features and Capabilities?

Both rental and local users indicated that they would be willing to pay about \$1000 for a TravTek-like system. Navigation and route guidance capabilities were valued about equally, and up-to-date traffic information was judged to be worth about half as much as the N and route guidance features. Users estimated that they would be willing to pay about \$35 dollars per week for a TravTek-like system in a rental car.

The Services and Attractions Directory in a new car was valued at about \$169 by renters and \$125 by local users. This discrepancy may have resulted because the TravTek Services and Attractions Directory was specifically tailored to be of most use to visitors. This suggestion is supported by rental and local users' nearly equal valuation of the Services and Attractions Directory in a rental car.

Users were nearly unanimous in agreeing that the TravTek system would be useful for out-of-town business and leisure travel. Both local and rental users were about evenly split as to whether the TravTek system would be useful for driving close to home. Younger drivers and more affluent drivers were more likely to judge TravTek useful for driving close to home.

Does TravTek Enhance Trip and Network Efficiency?

Other TravTek studies demonstrated trip planning time and travel time benefits associated with the route planning and route guidance functions. Those studies also suggest a network travel time savings benefit — reduced travel times for non-TravTek users — resulted from N+ users diverting away from the congested freeway thereby not adding themselves to queues already present.⁽⁸⁾ However, rental users did not perceive TravTek to help them avoid congestion. The failure to perceive a benefit may have been because of inadequacies in the sources of travel time information, or because those who were diverted could not observe, and thus appreciate, the congestion that they avoided.

Both local and rental users were mild in agreement with the assertion that TravTek helped them save fuel. Presumably they perceived the fuel savings to derive from more efficient routes, or reduced navigation errors, and not from congestion avoidance.

Debriefings. The debriefings of renters and local users were intended to capture impressions that are not readily obtained from structured questionnaires. The debriefings reinforced the finding that rental and local users most valued the route planning and guidance features of TravTek. The synthesized voice guidance feature was both liked and disliked. Users liked the Voice Guide because it enabled them to navigate well, yet keep their attention on the road. Virtually no one praised the sound quality of the synthesized speech and many said that it needed improvement.

CONCLUSIONS

The purposes of the Rental User Study and Local User Studies were to provide performance data from drivers who were free to use the TravTek system on their own, and to collect these drivers' perceptions of the TravTek system.

In terms of performance, both high mileage local drivers and renters visiting the Orlando area used TravTek on over 50 percent of their trips. Those with route planning and route guidance capabilities used the system to plan routes for over half their trips.

When using the route guidance feature, both renters and local users most often used the Turn-by-Turn Guidance Display supplemented by synthesized voice guidance. Although this was the default display configuration, usage of the display alternatives was sufficient to indicate that the drivers would have changed from the default configuration if they did not like it. Local users reported occasionally turning off the Voice Guide to avoid interruptions of radio programs, and suggested in the questionnaire that they had a slight preference of the Route Map (moving map) display.

Ratings of the TravTek system by users who had the N+ and N configurations were almost universally favorable. Users reported the system to be easy to learn, easy to use, and useful.

The traffic information provided by TravTek was not viewed favorably. Users did not perceive TravTek as helping them avoid congestion and were close to neutral in rating other aspects of the real-time traffic information features. As has been cited elsewhere, there were problems with the traffic information TravTek provide.⁽⁹⁾ Users appeared to separate their impressions of the TravTek traffic information from their judgments of the value of real-time information in general, as they indicated a willingness-to-pay a substantial amount for real-time information.

Fifty percent of local and rental users indicated a willingness-to-pay \$1000 or more for a TravTek system such as the one they drove. They indicated a willingness-to-pay of about \$600 for navigation, route guidance and route planning capabilities and about \$300 for real-time traffic information. Over 98 percent of users saw TravTek as useful for business and leisure travel, and just over half saw TravTek as useful for driving closer to home.

The TravTek Operational Test demonstrated that systems such as TravTek are useful and desired by both tourists and local drivers. Users of the TravTek system perceived benefits in terms of time savings, safety, and driving ease.

REFERENCES

1. Fleischman, R. N. (1991). Research and evaluation plans for the TravTek IVHS operational field test. *In Conference Record of Papers at the 2nd Vehicle Navigation and Information Systems (VNIS '91) Conference*, Dearborn, Michigan.
2. Peters, J. I., Dennard, D., Mammano, F. J. and Inman, V. W. (1993). TravTek Evaluation Overview and Recruitment Statistics. *In IEEE - IEE Vehicle Navigation & Information Systems Conference (VNIS 93)*, Ottawa, Canada, 108- 113,
3. Rillings, J. H., and Lewis, J. W. (1991, October). TravTek. *In Conference Record of Papers at the 2nd Vehicle Navigation and Information Systems (VNIS '91) Conference*, Dearborn, Michigan.
4. Carpenter, J. T., Fleischman, R. N., Dingus, T. A., Szczublewski, F. E. Krage, M. K., and Means, L. G. (1991). Human Factors Engineering the TravTek Driver Interface. *In Conference Record of Papers at the 2nd Vehicle Navigation and Information Systems (VNIS '91) Conference*, Dearborn, Michigan 749-755.
5. Dingus, T. A., Antin, J. F., Hulse, M. C. and Wierwille, W. W. (1989). Attentional demand requirements of an automobile moving-map navigation system. *Transportation Research - A*, **23A**, 301-315.
6. Dingus, T. A., McGehee, D., Hulse, M. C., Jahns, S., Manakkal, N., Mollenhauer, M., and Fleischman, R. N. (1995). *TravTek Evaluation Task C3 - Camera Car Study*. Federal Highway Administration, Technical Report No. FHWA-RD-94-076, Washington, DC, 1995.
7. Inman, V. W., Sanchez, R. R., Porter, C. L., and Bernstein, L. S. (1995). *TravTek Evaluation Task C1 - Yoked Driver Study*. Federal Highway Administration, Technical Report No. FHWA-RD-94-139, Washington, DC, 1995.
8. VanAerde, M. and Rakha, H. (1995). TravTek Evaluation Modeling Study. Federal Highway Administration, Technical Report No. FHWA-RD-95-090, Washington, DC, 1995.
9. Blumentritt, C., Balke, K., Seymour, E., and Sanchez, R. (1995). *TravTek System Architecture Evaluation*. Federal Highway Administration, Technical Report No. FHWA-RD-94-141, Washington, DC, 1995.
10. Inman, V. W., Sanchez, R.R., Bernstein, L. S. and Porter, C. L. (1995). *TravTek Evaluation Orlando Test Network Study*. Federal Highway Administration, Technical Report No. FHWA-RD-95-162, Washington, DC, 1995.
11. Perez, W.A., VanAerde, M., Rakha, H., and Robinson, M. (1995). *TravTek Evaluation Safety Study*. Federal Highway Administration, Technical Report No. FHWA-RD-95-188, Washington, DC, 1995.

12. Fleischman, R.N., Thelen, L., and Dennard, D. (1993). A preliminary account of TravTek route guidance use by rental and local drivers. In IEEE-IEE Vehicle Navigation & Information Systems Conference (VNIS 93), Ottawa, Canada, 120-125.